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GROWING FRUIT FOR HOME USE IN THE GREAT PLAINS AREA.

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CONTENTS.

	Page.		Page.
Introduction	1	Proper distances for planting	13
Sites for fruit plantations	4	Tillage	16
Climatic features of the Great Plains	4	Pruning	19
Preparation of the land for planting	7	Irrigation	27
Nursery stock	7	Orchard pests	28
Handling the stock when received from the nursery	9	Hail injury	29
Planting the trees and other nursery stock	11	Fruit varieties suggested for planting	30
		Mixed planting advisable	39

INTRODUCTION.

During recent years a transformation of large import has been taking place in the Great Plains area. From a vast territory devoted largely to the grazing of cattle and with a very small population it has become an area in which great quantities of grain and other crops are produced annually, with a corresponding increase

NOTE.—This bulletin is intended especially for those in the Great Plains area who are interested in growing fruit for home use, but some parts of it, especially the discussion about pruning and shaping trees, are of general interest to people living in other sections of the country.

The information is based largely upon the results obtained in a dry-land fruit garden which was established in 1908 at the Dry-Land Agriculture Field Station of the Bureau of Plant Industry, Akron, Colo. Most of the illustrations are from photographs taken in this garden.

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in the number of homes. Though some sections are still very sparsely settled, the aspect of the entire area has been materially changed by the influx of people who have come from many different parts of the country.

The Great Plains area is not "a natural fruit country," as those regions in which native fruits abound or where the conditions are especially favorable for fruit production are often called. On the other hand, very few native fruits occur in this area, and comparatively little attention has been given to the planting of the cultivated fruits. However, many of the recent comers are from sections where they have been accustomed to grow what fruit was needed for home use. It naturally follows that in many instances upon establishing new homes in this area they have planted a few fruit trees. As a result there are numerous ranches widely distributed throughout the Great Plains where some attempts are being made to grow a home supply of fruit.

In a few instances orchards of some commercial importance have been developed. Most of these are the outgrowth of one or more of several conditions: (1) The location has proved to be exceptionally well suited to the growing of fruit; (2) the owner has had considerable experience in fruit growing before coming to this section; or (3) the owner, as he has gained experience here with a small orchard, has found himself better qualified for the details of fruit raising than the ranchers generally, and has gradually increased his fruit interests to good advantage.

The surplus fruit from the home orchards, as well as that produced in those of larger size, always finds a ready sale, buyers sometimes driving many miles to obtain it.

Within the boundaries of the Great Plains area there are a few restricted districts that are under irrigation. In some of these, orchard interests of considerable commercial importance have been developed. These interests are not discussed, however, in this bulletin.

The tree fruits that occur most commonly in the dry-land ranch orchards are apples, cherries, and native plums. In some of the milder parts of the area, especially in the southern section, pears and peaches are more or less common, while still less frequently apricots are found. Currants and gooseberries are probably the most important as well as the most common of the small fruits. June berries, buffalo berries, and strawberries are sometimes to be found.

The successes and failures in this area, as in other sections, are quite largely dependent upon the care and attention given by the owner. In certain regions, however, it is difficult to succeed, while in others a complete fruit failure is comparatively rare. The one controlling factor in the Great Plains area, outside of those sections where water for irrigation is available, is the lack of moisture, yet

after the trees have become well established it is not often that this causes more than temporary loss, such as a crop of fruit for a single season.

In some sections winds and hailstorms occasionally cause damage, but these losses are not more frequent with fruits than with the field crops. However, the trees sometimes suffer permanent damage from hailstones, even being killed in some cases.

The majority of the settlers on the Great Plains must depend upon their own plantations for a supply of fruit for home use. Most of those who do not have home-grown fruit are obliged to do without it. The chief interest, therefore, in the cultivation of fruit in this area centers about the home and the production of enough to meet the needs or desires of each family. In other words, fruit growing here is a home-making rather than a money-making enterprise.

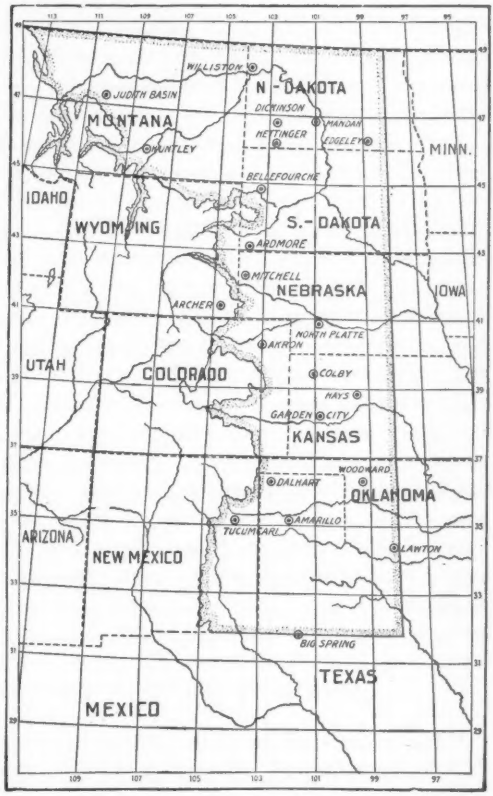

FIG. 1.—Sketch map of the Great Plains area, which includes parts of 10 States and consists of about 400,000 square miles of territory. Its western boundary is indicated by the 5,000-foot contour. Each dot within a circle (⊙) indicates the location of a field station of the Office of Dry-Land Agriculture Investigations of the Bureau of Plant Industry.

The geographical position and extent of the Great Plains area are shown in figure 1. Its western boundary, as indicated, is the 5,000-foot contour; its eastern boundary is arbitrarily placed at the ninety-eighth meridian.

SITES FOR FRUIT PLANTATIONS.

Probably the greatest obstacle, either directly or indirectly, to the successful growing of fruit in the Great Plains area is lack of moisture in the soil. It follows, therefore, that the site for an orchard or small fruit garden should be selected with a view to securing the maximum supply of soil moisture. In many instances, particularly on the smaller ranches, the conditions are so nearly uniform that there is no choice in this respect. The convenience of the site with regard to the buildings will usually be the ruling factor in such cases.

But on many ranches there are sites that are more favorable for fruits than others, on account of the soil-moisture factor; for instance, where a small stream or arroyo passes through the ranch it may furnish an additional supply of water. In some cases the topography is such that a reservoir can be made by building a small dam across the stream and diverting the water to the orchard. Not infrequently some of the larger streams that pass through this area have an underflow that extends some distance on either side. Where this condition prevails and the underflow is reached by their roots, the trees often make a remarkable growth.

Again, there are many instances where the lay of the land is such as to result in a large amount of run-off during heavy rains. If this run-off, which would otherwise be lost, can be collected in small contour ditches and distributed where fruits are planted, a considerable increase in the supply of moisture is secured. Sites for fruit plantings can be selected sometimes with reference to this possibility. Advantage should be taken of every factor which will increase or conserve the supply of moisture in the soil.

CLIMATIC FEATURES OF THE GREAT PLAINS.

"The climate of the Great Plains has been classified as semiarid. It may be better to say that it is variable. One season may have almost humid and another almost arid conditions. The mean annual precipitation is relatively low. Years of relatively high precipitation may be followed by years of relatively low precipitation. Other climatic factors usually correspond with the rainfall. In a year of relatively high rainfall there will be a lower rate of evaporation and higher humidity than in a year of low rainfall.

"Another climatic factor of much importance in crop production on the Plains is the distribution of the rainfall. This is probably more important in crop production than the amount of annual rainfall. A relatively low rainfall, properly distributed, may produce a crop where a much higher rainfall, unfavorably distributed, may accompany a crop failure.

TABLE I.—*Annual and seasonal precipitation and seasonal evaporation at fourteen stations in the Great Plains area.*[1]

Station.	Altitude (feet).[2]	Precipitation (inches).[3]						Seasonal evaporation (inches).[3]		
		Annual.			Seasonal.					
		Minimum.	Maximum.	Average.	Minimum.	Maximum.	Average.	Minimum.	Maximum.	Average.
Judith Basin	4,228	14.96	23.78	18.06	7.04	17.21	9.34	22.012	29.353	24.491
Huntley	3,000	11.92	11.92	11.92	5.92	6.02	5.97	23.754	24.214	23.984
Williston	1,875	10.28	18.99	14.84	4.75	14.49	9.66	20.422	26.877	24.216
Dickinson	2,543	11.93	21.22	16.69	6.85	16.28	9.79	20.673	25.745	23.919
Edgeley	1,468	11.94	21.95	16.71	7.85	14.98	10.11	18.663	24.893	21.866
Hettinger	2,253	12.72	15.68	14.20	8.92	12.47	10.36	21.539	28.239	24.639
Belle Fourche	2,950	6.64	17.73	13.11	4.08	9.78	6.90	26.472	33.750	28.794
Scottsbluff	3,950	13.77	18.51	16.14	2.53	8.52	4.69	23.804	29.381	26.081
North Platte	3,000	11.18	23.01	18.05	6.85	12.36	9.45	28.445	38.168	32.359
Akron	4,600	14.51	22.46	18.28	6.42	13.86	9.02	26.064	35.654	31.420
Hays	2,050	15.59	27.80	21.30	8.18	17.97	11.17	30.625	44.373	35.790
Garden City	2,900	11.82	23.58	18.54	2.79	14.43	8.65	34.325	43.510	38.185
Dalhart	4,000	13.69	16.35	15.11	5.09	9.85	8.01	35.459	41.748	38.988
Amarillo	3,676	10.69	27.80	18.28	6.17	11.38	9.13	33.804	42.076	36.724

[1] The period of time covered by the investigations made at the several stations ranged from two to eight years, depending upon the time when the different stations were established, the same period being covered by the data regarding precipitation and evaporation shown here.

[2] The altitude given is based in most cases on that of the nearest town.

[3] The records of annual precipitation for 1914 are not included. The records of seasonal precipitation and evaporation for 1914 are included for all stations, being figured from May 1 to Sept. 1. Evaporation measurements are made from a free water surface, in a tank sunk into the soil to almost its full depth. The water surface is kept about level with the surface of the ground.

"Table I gives the maximum, minimum, and average annual precipitation and the seasonal maximum, minimum, and average precipitation and evaporation of the Great Plains area. By seasonal is

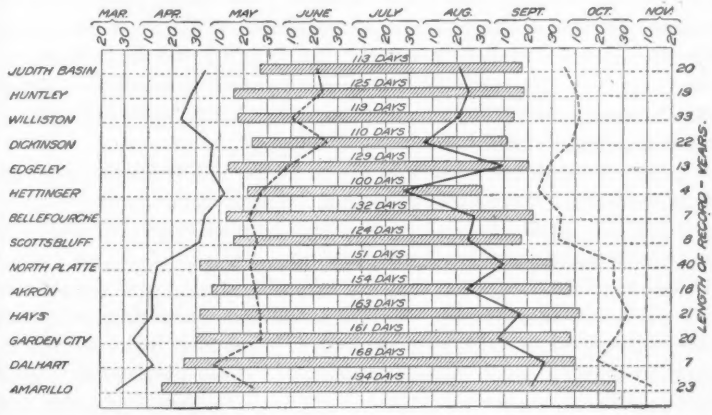

FIG. 2.—Diagram showing the average frost-free periods and the earliest and the latest dates at which the last killing frost in the spring and the first killing frost in the fall has occurred at fourteen stations in the Great Plains area.

meant the period between the average time of seeding and the average time of harvest. * * *

"Figure 2 shows the earliest and latest dates of the last killing frost in the spring, the earliest and latest dates of the first killing frost in

the fall, and the average length of the frost-free period at each station. Each hatched horizontal bar represents the period between the average dates of the last killing frost in the spring and the first killing frost in the fall. The number of days in the average frost-free period for the station is shown in the figures above the bar. The solid-line curve at the left shows the earliest date at which the frost-free period has begun. The broken-line curve at the left represents the latest date at which the last killing frost of the spring has occurred. The solid-line curve at the right represents the earliest date and the broken-line curve at the right the latest date at which the first killing frost of the fall has occurred.

"This diagram [fig. 2] shows clearly the increase in the length of the frost-free period from the north to the south. The shortest average period is 100 days, at Hettinger, and the longest 194 days, at Amarillo."[1]

In the Great Plains area the regional restrictions to fruit growing, so far as the natural conditions are concerned, are primarily factors of temperature and moisture.

In some sections of this area, especially the northern part, fruits for planting must be selected with a view to their hardiness and their ability to endure extremely low temperatures in winter. But throughout the Great Plains area as a whole unseasonable frosts during the blossoming period or at other critical stages of growth more often cause damage than extreme cold during the dormant period. However, the combination of relatively low winter temperatures, limited moisture supply, and drying winds that sometimes prevail is extremely trying on most fruit trees and may cause serious damage where any one or even two of these factors operating at the same time would not adversely affect the trees.

The general climatic features of this area are well indicated in the paragraphs above quoted. In that connection the statements are applied to the production of general agricultural crops, but they are none the less applicable to fruit growing.

Another climatic factor that occasionally does great damage is hail. Trees of considerable size are sometimes completely killed or so badly bruised or otherwise injured as to render them worthless. Hailstorms occur much more frequently in some parts of this area than in others. In sections where they are known to be severe, the planting of fruits is likely to prove disappointing.

Some sections of the Great Plains are further characterized by winds which blow almost continuously. While the wind may not be a prohibitive factor in the growing of fruit in any section it is

[1] See Chilcott, E. C., Cole, J. S., and Burr, W. W., "Crop production in the Great Plains area: Relation of cultural methods to yields," U. S. Dept. Agr. Bul. 268, p. 4, fig. 2. 1915.

a serious one where it blows much of the time. It not only results in the premature dropping of the fruit, but it becomes practically impossible to prevent the tops of the trees from growing very much to one side.

PREPARATION OF THE LAND FOR PLANTING.

For fruits, land that has been in cultivation for one season or for a sufficient length of time for the sod to have become thoroughly rotted is very much to be preferred to newly broken land.

The planting of fruits in this area should be done as a rule in the spring, and in any special preparation that may be made the aim should be to handle the soil so that it will contain as much moisture as possible at the time the planting is done.

In seasons of fairly abundant precipitation, especially if there is considerable rainfall or fairly heavy snows during the winter, there may be enough moisture stored in the soil in the spring to insure the starting of the trees, even if a crop has been produced the previous season. But because of the wide seasonal variation in the amount of precipitation, frequently falling far below normal, and the importance of an abundant supply of soil moisture in the spring at planting time, it is generally advisable to summer-fallow during the season that precedes the planting.

In addition to summer-fallowing, an adequate supply of soil moisture is still further insured if deep furrows are opened in the fall along the lines of the tree rows. These will serve to collect both the drifting snow and some of the run-off during heavy rains which might otherwise be lost.

One very successful fruit grower on a dry-land ranch even supplements the furrows by digging in the autumn rather large holes where the trees are to stand. The run-off, as well as the snow caught in the furrows, will tend to settle in the holes and thus still further augment the amount of moisture in the soil in the immediate radius of the trees. In some cases, cross furrows or furrows made at an angle to the direction taken by the run-off and leading to the holes might also be useful.

Under ordinary climatic conditions this method of preparing the land should result in its being well supplied with moisture, and the trees should start into growth readily and make a good development of roots so far as the soil moisture is concerned.

NURSERY STOCK.

In the central portion of the Great Plains area, as represented by the Akron Field Station, Akron, Colo. (fig. 1), the most favorable period for planting is usually the last of April and early in May.

It varies in other parts of the area from earlier in the southern section to somewhat later farther north. Normally, nursery stock is delivered in the spring rather than in the autumn. It is absolutely essential for success that it reach its destination in a perfectly dormant condition. Hence, it follows that while it may be satisfactory for those ordering stock for planting in the southern part of the area to secure it from northern sources, it is not well to obtain it from the south for planting in the northern sections, on account of the fact that the buds may start on stock from the south before the most favorable period for planting in the north has arrived.

On account of the arid or semiarid conditions of this region the period following the planting of the trees is very trying unless there is a sufficient supply of moisture stored in the soil and available for their use. The moisture in the trees is being dried out constantly, and more rapidly than would be the case in a humid region. The roots of newly planted trees do not at first readily take up moisture from the soil, and if it is excessively dry the trees may die before they can start into growth. Because of these moisture factors it is of the greatest importance to secure only trees and other nursery stock which are most likely to start into growth readily and quickly when planted.

In many fruit-growing regions apple, pear, plum, and cherry trees are commonly planted when 2 years old; that is, after they have made two seasons' growth in the nursery from the bud or graft. However, in some commercial apple and cherry growing sections there is a strong sentiment in favor of 1-year-old trees for planting in preference to older ones. The younger trees have an advantage in that it is possible to form the tops at any desired height. The heads are already formed on 2-year-old trees when received. Not infrequently the trees have been headed too high to be desirable, and it is not always possible or practicable to plant such trees deep enough to overcome this objection. And, again, good, strong 1-year-old trees as a rule withstand transplanting fully as well as older trees; they are lighter to handle in shipping and in other ways are more desirable. This is true of other trees as well as of apples and cherries.

Inexperienced buyers of fruit trees not infrequently measure the value and grade of the trees delivered by their size; the larger the tree the better it is supposed to be. But experience has proved that thrifty, medium-sized trees are better for planting in the Great Plains area than larger ones, with a preference for good, strong 1-year-old trees. The larger 2-year-old trees as a rule do not withstand transplanting as well, nor are they as likely to live and make a good growth as the medium-sized ones of the same age.

On the other hand, a very radical distinction must be made between medium-sized or relatively small healthy trees and those

which are small because they have been stunted by some adverse condition. Weak, stunted trees should be refused absolutely. They are likely to be expensive even as a gift.

Good root systems are also of special importance in satisfactorily starting trees planted under the conditions which normally prevail in this area. In sections where all the factors influencing growth are favorable, the difficulties incident to poor roots, if not too serious, may be overcome perhaps without permanently harmful results; but in the region under consideration well-developed and abundant root systems are especially important. If the roots of trees consist of only a very few large parts, new growth does not start as readily and as quickly as it does if the plants are well provided with a large number of small roots.

But here again caution is necessary. A large mass of very fine threadlike roots is due cause for suspicion. Such roots may indicate a disease known as hairy-root, a form of crown-gall. While there is a wide difference of opinion and experience concerning the seriousness of this trouble, it is by far the safer plan to discard trees so affected; the roots in any event are abnormal and if planted there is always the possibility that the trouble will develop to such an extent as to affect seriously the vigor and durability of the tree. All trees and vines showing crown-gall or abnormal growths of any kind should be rejected.

The height of the tree is as important as its root system. Trees that have been headed from 1½ to 2½ feet high as a rule start into growth more readily and develop better than trees headed 3 to 3½ feet high. In a large majority of cases the high-headed trees, even when they live, make only a very small growth the first season and rarely develop well-formed, satisfactory tops as they increase in age.

HANDLING THE STOCK WHEN RECEIVED FROM THE NURSERY.

It has already been stated that planting in the spring rather than in the autumn is to be advised in this area. To insure the timely arrival of the stock from the nursery it is wise to order it shipped with a view to its arriving at its destination a little in advance of the actual date of planting. Otherwise, an unexpected delay in shipping or during transit may result in inconvenience or in the undue starting into growth of the stock before it is received.

To hold trees and other plants in good condition until planted, they should be unpacked immediately upon arrival and heeled in without delay in a well-drained spot. The heeling in is accomplished by digging a trench 12 or 15 inches deep, sloping on one side. The roots are placed in the trench, the trunks of the trees lying at right angles to it on the sloping side. The position is illustrated in figure 3.

In case the trees are tied in bundles when received they should be separated; otherwise, the roots can not be properly protected. Moist, finely pulverized soil should then be worked thoroughly in among the roots, completely filling all the spaces, and the roots finally covered several inches deep.

If it is necessary for any reason to have the trees heeled in for a long time before they are planted, it may be advisable to cover the tops, entirely or nearly so, with soil, to prevent the sap from being dried out to an undue extent. With the first advent of warm weather, however, the branches should be uncovered.

The soil that is placed over the roots and such other parts of the trees as may be covered should be packed very firmly. This is not

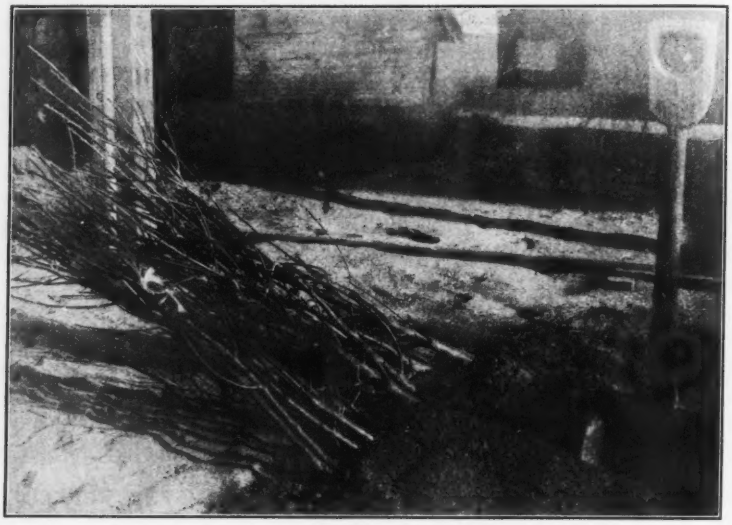

FIG. 3.—Peach trees heeled in. The position in which the trees are placed is to be noted.

only for the purpose of excluding as much air as possible, but to lessen the danger of mice finding a harbor among the trees, where they might cause injury by gnawing the bark.

Trees that are heeled in should be examined frequently, with especial reference to moisture conditions. While the soil about the roots should not be kept in a water-soaked condition, it should not be permitted, on the other hand, to become thoroughly dry. The sap in the trees would be likely to dry out and the bark shrivel if this should occur. Difficulties of this sort can be avoided easily by the judicious application of water.

Berry bushes and other small fruits are handled in essentially the same manner as trees, but the trenches in which the roots are

placed are shallower than for tree fruits, to correspond with the size of the plants.

PLANTING THE TREES AND OTHER NURSERY STOCK.

The most satisfactory time for planting fruit trees and bushes in eastern Colorado in the average season is the last of April or the first of May. The soil is usually in good workable condition at this time, and as a rule it is a period during which there is considerable precipitation. These conditions are favorable for growth, and if a tree or other plant reestablishes itself readily in its new place and growth begins promptly one of its most critical periods is past.

The best time for planting fruits in the other parts of the Great Plains area may vary somewhat from the dates for Colorado given above. Generally, it may be done earlier in the southern sections and later in the north. It should be done after the danger of hard freezing temperatures is past and when the soil is in good condition for working.

The method of planting fruit trees in this area does not differ in any essential from that commonly followed in other parts of the country. In handling the trees every possible precaution needs to be taken to prevent the roots from becoming dry when the trees are removed from place to place. The roots should not be exposed to the air more than is absolutely necessary. Covering with wet burlap is, perhaps, the most convenient means of giving protection, but wet chopped straw, damp moss, or other materials that can be moistened and covered over the roots may be made to serve the purpose; or the roots may be protected by puddling them. This consists merely in dipping the roots in a puddle of clay. The clay should be of such consistency that a thin layer of mud will adhere to the roots when they are dipped into it and at the same time permit them to be moved about in it with perfect ease and freedom. Such a coating of mud will afford considerable protection against undue drying out from exposure to sun and wind. By observing this precaution at all times, including the period of exposure incident to planting the trees, there should be no loss due to dried-out roots.

The holes are made broad enough to receive the roots without bending them from their natural position and deep enough so that when filled even with the surrounding surface the trees will stand 2 or 3 inches deeper than they did in the nursery. Sometimes the holes are made in the autumn, as previously described.

Before planting, the ends of all broken roots and roots otherwise injured should be removed with a smooth cut. As the trees are placed in position in the holes the soil is carefully worked around the roots and firmly packed by tramping. If the soil is moderately moist it will not be necessary as a rule to water the trees when

planted; but if the soil is dry it may be well to pour a pail or two of water into the hole after it has been partially filled with soil, and then complete the filling after the water has soaked in. The subsequent use of water should be governed by conditions. If it continues dry after the trees are planted an occasional application of water sufficient to keep the soil in the vicinity of the roots well moistened may enable the trees to grow readily when otherwise they might fail entirely from lack of moisture.

When the trees are planted they should be headed back to the desired height. It is believed from experience and observations under Great Plains conditions that the main stem or trunk of the tree should not exceed 2 or 2½ feet in height, measuring from the surface of the ground after the tree is planted. In many cases the heads may well be formed even lower than this. Trees with low heads are not as likely to be injured by sun scald as those with high heads, nor are they as much affected by the wind. If the trees have been headed in the nursery, as is the case with stock 2 years old, it is often impossible to handle them so as to place the heads at the desired height. With 1-year-old trees this difficulty does not exist.

There is a wide difference of opinion and practice among fruit growers as to the details to be observed in shaping the permanent head of the tree, but the conditions attending tree growth in this area are such that it is believed an open head which develops from a few main branches is preferable to one so managed that it becomes dense and bushy.

To develop an open head, only four to six branches should be left when the tree is pruned at the time it is planted, or when it is formed later if 1-year-old trees have been used. These branches should be selected with a view to their position on the trunk. They should be arranged symmetrically and spirally about the trunk and should start from different levels, thus leaving some space vertically between the different limbs. If two limbs branch from the trunk at the same level there is much more danger that they will split down in later years under the weight of a large crop of fruit or during a heavy wind than where the formation is as suggested above.

The branches selected for the permanent top of a 2-year-old tree should be cut back considerably at the time the tree is planted. If the tree has made a fairly vigorous growth in the nursery the preceding season, one-half or two-thirds of the length, as a rule, may be cut away. This will tend to make the branches strong and stocky rather than slender and "leggy," as when no cutting back is done.

This plan of forming the head also reduces the number of branches which the roots are required to supply with moisture during the first season's growth. It should be kept in mind that a considerable

portion of the root system is lost in digging the tree from the nursery and that the branches need to be reduced proportionally.

The plan described is illustrated in figure 4 and still further shown in figures 5 to 10. Figure 4 shows a McIntosh apple tree in July of its second season's growth in the Akron fruit garden. It was headed low, the number of permanent branches was reduced to four or five, and from the very beginning the top has been kept open. The same plan of development may be seen in the other illustrations mentioned.

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FIG. 4.—A McIntosh apple tree in July of its second season's growth, which has been pruned with a view to developing an open head. Akron, Colo., July 19, 1913.

The method followed in planting small fruits is essentially the same as that described for tree fruits. They are planted, as a rule, a little deeper than they were originally. They are cut back, if necessary, to make the tops correspond to the root system, and in other respects the directions given above are readily adapted to handling small-fruit plants.

Because the roots of small fruits are nearer the surface than those of tree fruits it may be necessary to give more attention to watering newly set plants until after they start into growth than is suggested for trees. This applies with special emphasis to strawberries.

PROPER DISTANCES FOR PLANTING.

The distance between fruit trees is a matter of greater importance than is commonly realized. The space unoccupied at the time the small trees are planted seems out of proportion to their size, but the requirements when the trees are mature must be anticipated. It

should be remarked that the roots extend very much farther than the spread of the branches, contrary to a commonly expressed notion. At Cheyenne Wells, Colo., the roots of a 14-year-old apple tree were traced 26 feet in one direction from the tree and some 9 or 10 feet in the opposite direction, making a spread of at least 35 feet; in fact, the actual spread was several feet more than this, as it became impracticable to trace the roots in the very dry, hard soil to their ends.[1]

P15962HP

FIG. 5.—A Delicious apple tree after two seasons' growth as it appeared before its annual pruning. The foundation for the top consists of four or five main limbs.

P15963HP

FIG. 6.—The Delicious apple tree shown in figure 5 after being pruned. Both figures were reproduced from photographs taken at Akron, Colo., November 12, 1914.

The great number of roots that develop on apple trees under semiarid conditions is suggested by figure 11, and the expanse of the roots is shown in figure 12. It was 26 feet from the stump to the end of the root held by the man shown on the left in the illustration (fig. 12).

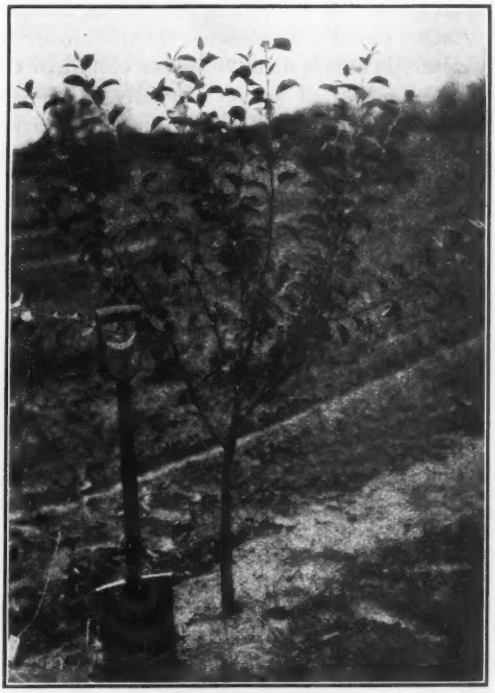
It therefore appears that trees may suffer earlier in their life from the crowding of the roots than from the crowding of their tops. The bearing which these facts have on the welfare of the trees is

[1] This study of the root systems was made in August, 1910, at the Dry-Land Substation of the Colorado Agricultural Experiment Station by Mr. J. E. Payne, then connected with that station, and one of the writers. For further details, see Payne, J. E., "Notes on a dry-land orchard," Colo. Agr. Exp. Sta. Bul. 173, 7 p., illus. 1910.

largely in relation to the moisture supply. If the trees are too close together their combined moisture requirements may exceed that furnished by normal precipitation.

Too close planting is a common fault in many of the commercial fruit-growing districts in irrigated as well as in humid sections. Its results in semiarid sections where irrigation is not practiced are likely to be particularly serious.

While fruit trees may not grow as large under the semiarid conditions of the Great Plains as in humid sections, it is not believed that this fact is sufficient to warrant close planting. On the other hand, the size attained here by trees is likely to be governed very largely by the amount of moisture available.



P16305HP

FIG. 7.—The same Delicious apple tree shown in figures 5 and 6 as it appeared in July of the following season. The buds near the ends of the stubs in figure 6 have developed into branches, thus making a good framework for the development in the future of a strong well-branched tree. Akron, Colo., July 21, 1915.

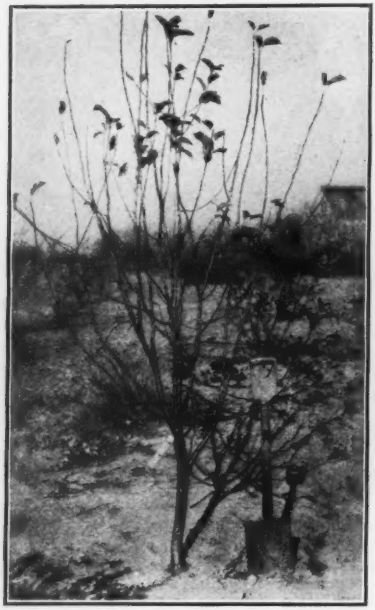
In the light of the foregoing statements the following distances each way for the planting of different fruits are suggested:

Apples, 30 to 35 feet.
Pears, 25 to 30 feet.
Peaches, 20 to 25 feet.
Plums, 20 to 25 feet.
Cherries, 20 to 25 feet.
Sand cherry–plum hybrids, 10 to 15 feet.
Currants, 5 to 6 feet.
Gooseberries, 5 to 6 feet.
Raspberries, 6 to 7 feet.
Blackberries, 6 to 7 feet.
Strawberries, usually in rows 3 or 3½ feet apart, with the plants 1½ to 2 feet apart in the row.

Many of these distances may seem excessive at first, but they allow none too much space when the demands of mature trees and other plants for moisture and plant food are taken into account.

TILLAGE.

The tillage (or cultivation, as it is more commonly termed) of a fruit garden or orchard in this region should be very thorough. Its primary object is to conserve the soil moisture to the greatest possible extent. If this is done, the other objects of tillage will generally follow as a matter of course. Usually, it should be continued fairly late in the season. In 1910 the seasonal cultivation in the dry-land ranch garden at Akron was discontinued early in August. This was done



P15949HP

FIG. 8.—An Utter apple tree after its third season's growth as it appeared before its annual pruning. In previous years the pruning has been directed toward keeping the top open.

P15950HP

FIG. 9.—The Utter apple tree shown in figure 8 after being pruned. Both illustrations (figs. 8 and 9) were reproduced from photographs taken at Akron, Colo., November 11, 1914.

in order to avoid further stimulation of growth and to insure a thorough ripening of the wood before the advent of cold weather. However, no beneficial results followed that could be attributed to the cessation of cultivation as early as this; and, besides, it might prove a rather hazardous plan in some seasons. The growth of weeds following the cessation of cultivation so early in the season was sufficient to make a serious drain on the supply of soil moisture. The danger lies in the fact that the moisture in the soil might be reduced

to such an extent that the trees would suffer during the winter or the following season in case there was little precipitation.

Tillage in the garden at the Akron Field Station has been frequent enough to destroy weeds before they have made any considerable growth, to prevent the soil from blowing, and to insure against any run-off during heavy showers. To these ends the surface has been kept in a rough, granular condition. In accomplishing these objects, the soil moisture has been well conserved against evaporation from the surface. Tillage has usually been continued until the latter part of August, or late enough to prevent any considerable growth of weeds and to avoid all danger of their going to seed.

P1C506HP

FIG. 10.—The same Utter apple tree shown in figures 8 and 9 as it appeared in July of the following year. Akron, Colo., July 21, 1915.

This practice with regard to tillage has given good results in the Akron garden. Moreover, in its general principles it has been followed by ranchers in other sections of this area in the successful growing of fruit. Slight modifications of this plan of tillage may be necessary under some soil and climatic conditions, but it is believed that it embodies the essential features, so far as this operation is concerned, in maintaining orchards and fruit gardens in this area, not only while they are young, but after they reach maturity.

Clean tillage throughout the season during the early life of an orchard amounts practically to summer fallowing. During the first three or four years and before the roots have extended very far, the demands made by the trees upon the soil moisture are compara-

tively small. With normal precipitation, the tendency obviously would be for the percentage of soil moisture in the spaces between the trees to increase rather than to decrease under this method of management. In this way, the greater demands of the trees for moisture as they reach larger size are anticipated in a measure, at least for a time.

Cover crops and green-manure crops serve a most important purpose in maintaining the fertility of orchard soils in humid and irrigated sections, but in this area where the soil moisture is so largely the limiting factor their use rarely, if ever, can be advised. The growing of these crops usually would draw so heavily upon the

P613IHP

FIG. 11.—Part of the root system of a 14-year-old Ben Davis apple tree. Colorado Experiment Station, Plains Substation, Cheyenne Wells, Colo., August 11, 1910.

moisture in the soil that they would be a menace rather than a benefit to the fruit. The humus furnished by such crops in sections where they can be grown must be supplied here by applying manure or vegetable matter in some other form.

For a similar reason the interplanting of crops between the rows of trees in young orchards, as is commonly done in commercial fruit-growing sections, can not be recommended in this area. In the case of apple trees planted 30 or 35 feet apart, a row or two of corn or some vegetable possibly could be planted for the first two or three years midway between the rows of trees without irreparable harm to the latter, but the wisdom of even this limited competition with the trees would be doubtful in most cases.

The tools used in cultivating fruits may be a disk harrow, corn cultivator, or shovel cultivator, as conditions or convenience may dictate. While there are specially constructed orchard-tillage implements, the same tools used in the cultivation of general crops may be used advantageously in most cases.

PRUNING.

There is probably no phase of fruit growing on the Great Plains which requires greater care and attention in order to secure the best results than the operation of pruning. While this is especially true of tree fruits it is also of importance with small fruits.

One of the commonest faults to be found with fruit trees on many ranches in the Great Plains area is the density of the tops. This

P8135HP

FIG. 12.—The same stump of a Ben Davis apple tree shown in figure 11. The roots were traced a distance of 26 feet on the left and 9 or 10 feet on the right. The small extremities of the roots, amounting probably to several feet in length, still remained in the soil.

fault, however, is not more characteristic of fruit growing in this area than it is in many other parts of the country. It is a natural consequence in the first place of planting trees without properly forming the heads at the time they are set out and of improper pruning or no pruning at all in after years. In fact, as will be illustrated later, it is often practically impossible to correct the faults incident to improper pruning at the time of planting by pruning when the trees are several years old.

If only a single idea were to be kept in mind in pruning a fruit tree throughout its life, that idea might well be to keep the top sufficiently open to admit air and sunshine freely. If this is accomplished, most of the other objects for which fruit trees should be pruned will also be realized.

The fear that the branches will be injured by exposure to the sun is frequently offered as a reason for allowing the tops to become very dense. It is true that where a large limb which has been shaded continually is suddenly exposed to the direct rays of the sun serious injury may result, but when a tree is grown from the beginning with an open head and is properly pruned there is little danger from this cause.

In further understanding the principles of pruning, the reader will be assisted by reference to the accompanying illustrations, most of which are made from photographs taken in the Akron fruit garden.

Figure 4, previously referred to in connection with the planting of trees, shows also the pruning which was done following the first season's growth. The limbs were cut back to the points just below the level of the upper part of the spade handle, where the secondary branching may be seen. Branches which may have crossed each other and other superfluous growth were also cut out. While the top is open, it will be observed that the main limbs are well protected by leaves that developed from short spurs or buds. In a very dense top there would be but little development of leaf-bearing spurs along these limbs. The photograph reproduced here was taken in July, 1913. A good, strong current season's growth is evident. This growth would normally be headed back during the dormant season following the growth made in 1914, and such thinning out as might seem necessary to maintain the top in a well-opened condition would be done at the same time.

Figure 5 shows a Delicious apple tree that was planted in the spring of 1913. The top was lightly pruned in July of that year, the superfluous branches being removed. This figure shows the tree as it looked in November, 1914. The current season's growth of some of the branches was 2 to 3 feet, with practically no side branches. Figure 6 shows the same tree after it had been pruned. The results of this heavy heading back in November, 1914, become apparent by reference to figure 7, which shows the same tree in July, 1915; that is, during the middle of the following season's growth.

The strongest growth has taken place from buds near the ends of the stubs of branches shown in figure 6. This is resulting in a well-proportioned stocky tree, yet one which can be kept well opened to the air and sunshine with a minimum amount of pruning. Had this tree been left, as shown in figure 5, without heading back, the branching during 1915 would have occurred probably from buds near the ends of the branches, thus making a top composed of long, slender, "leggy" limbs instead of having the compact framework that is seen developing in figure 7. Perhaps this tree is not quite as tall now as it was in figure 5 before it was pruned in November, 1914,

but it is more stocky and in better shape for its future development than it would be if it had not been headed back.

Figures 8 and 9 illustrate still further the idea expressed in figures 4 to 7 with reference to developing trees with stocky, open tops. These show an Utter apple tree that was planted in the spring of 1912. The photographs from which these illustrations were made were taken in November, 1914, before and after pruning. The tree then had completed three seasons' growth. From the beginning, it has been handled with a view to keeping the top open. As may be seen from figure 8, in comparison with figure 9, it was necessary to remove but little wood at this pruning, even though the current season's growth had been quite strong, many of the limbs having increased 2 feet or more in length. The tree was started the first year with a framework of four or five branches. With these to serve as a foundation and with a small amount of corrective pruning each year the tree remains within easy control.

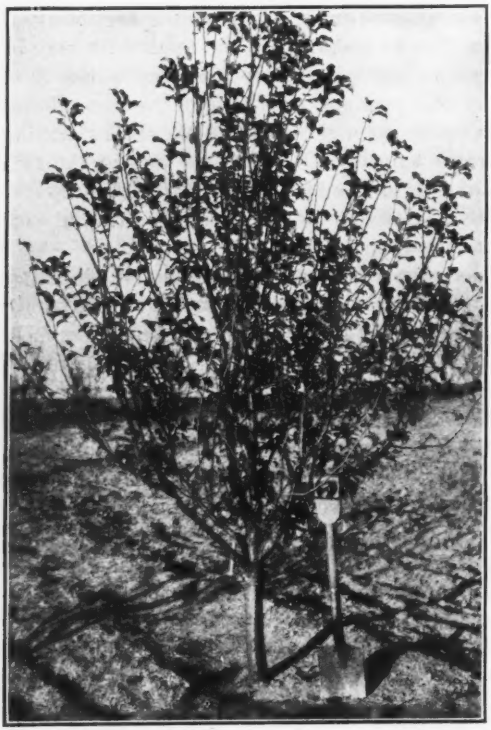
In contrast with the average apple tree to be found in this area, the one shown in figure 9, as it here appears, may seem to many to be entirely too open. During the next season, however, the development of leaves and many small side branches, which may be expected eventually to form fruit spurs, causes the tree to present a very different appearance, as shown in figure 10. As seen here it is in its fourth season's growth. It will not be headed back very much in the pruning which it receives in the future. Heavy heading back tends to stimulate additional wood growth. This tree has now been well shaped. The limbs that form the framework of the top, as well as the trunk, are stocky and strong. It is in good condition to begin to bear fruit. There is, therefore, no further need of pruning to encourage additional wood growth, but more or less thinning out of the top probably will be necessary each year. Slight heading in at times may be advantageous, but the foundation work, so far as pruning is concerned, has now been completed.

The keeping of the top well opened during the first few years is favorable for the development of spurs and short branches along the limbs, thus tending to the production of a large bearing surface. It is on such growth that many fruit buds subsequently develop. This so distributes the fruit on the main limbs that there is the least possible danger of their breaking from its weight.

It should be stated, however, that there is much yet to be learned about the effect of heading back the annual growth year after year. If trees with strong stocky limbs are to be developed, rather heavy heading in for several years after planting seems as a rule to be necessary. On the other hand, there is considerable evidence that if this practice is carried too far it very materially retards the time of bearing. Moreover, in this respect, it seems probable that trees

of different varieties should be handled differently. Some varieties naturally make a strong stocky growth and do not branch excessively, while others develop long, slender branches. Obviously these two types of trees should be treated differently with respect to pruning.

It is, of course, desirable that a tree should come into fruiting as early as possible after it is planted, but the gain of a year or two in earliness of bearing is of small importance compared with the development of a type of tree which in later years will best meet the ends for which it is grown. It is the nice balance between earliness of bearing and other characteristics and the development of a tree which in the long run shall be best suited to fulfill the ends in view that constitutes the real problem in pruning during the early life of an orchard.

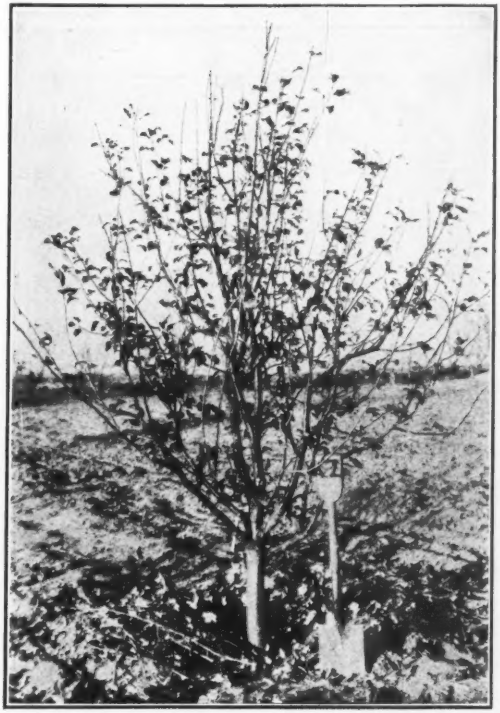


P15966HP

FIG. 13.—A Wealthy apple tree planted in the spring of 1908, which received no further pruning until after its third season's growth. Because of these years of no pruning it has not been possible in more recent years to bring the top to a desirable form. Akron, Colo., November 11, 1914.

In rather strong contrast to the trees shown in figures 4 to 10 are those in figures 13 to 17. The latter illustrate apple trees planted in the spring of 1908. The photographs used in making these illustrations were taken in November, 1914, after the trees had completed their seventh season's growth. Because these trees are considerably older than those shown in figures 4 to 10, the illustrations in the two groups are obviously not entirely comparable. Yet they show certain contrasts that are of fundamental importance in pruning fruit trees at the time of planting and during the first three or four years thereafter.

In contrast to figures 4 to 10, figures 13 to 17 show apple trees that were not trimmed with any particular ideal in view when they were planted, and they received no further pruning until after they had completed their third season's growth in 1910. Since then they have been pruned each year. To the casual observer the objectionable features of these trees may not be conspicuous, but they become very real to the one who wishes to prune them in a rational manner.



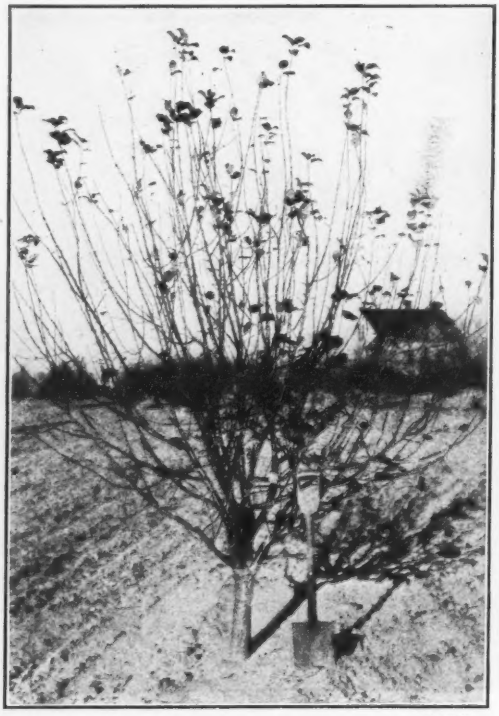
P15987HP

FIG. 14.—The Wealthy apple tree shown in figure 13 after being pruned. Akron, Colo., November 11, 1914.

Figures 13 and 14 show a Wealthy apple tree and figures 15 and 16 a Patten tree in November, 1914, before and after pruning. Figure 17 is a Northwestern apple tree not yet pruned in 1914. It will be seen by reference to the figures showing the trees before pruning that the tops are not extremely dense, as at the time the photographs were taken (Nov. 11, 1914) a good deal of the foliage had dropped. When the pruning was begun in 1910, following three years of unrestricted growth, the tops of these trees were veritable heaps of brush. The pruning since 1910 has been directed primarily toward the gradual removal of superfluous wood. However, because of the fact that the trees were not well formed at the time they were planted and during the first year or two thereafter, the pruning in subsequent years has failed and must continue to fail to reduce the work to the simple, systematic operation that it is in the case of trees that are well pruned from the beginning. Most of the branches in these three trees (figs. 13, 15, and 17) are relatively long and slender because they radiate so largely from a common axis

or from nearly a common center. To keep the tops suitably pruned is difficult. If one of the larger limbs with its component branches is removed to open the top, the result is an unsymmetrical head; one side is made considerably lighter than the other.

The alternative in maintaining the tops sufficiently open for the free access of sunshine and air is to cut away a considerable number of the smaller branches. This tends toward the development of long slender unbranched limbs, with the bearing surface a little later in the life of the trees occurring only near the extremities.



P15960HP

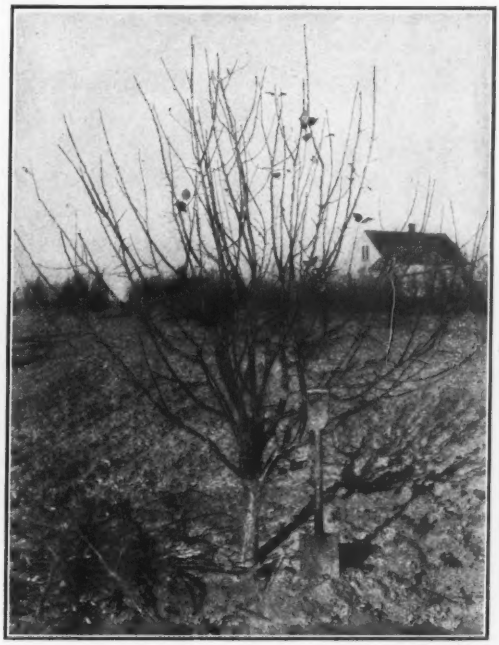
FIG. 15.—A Patten apple tree planted in the spring of 1908, which has received treatment similar to that of the Wealthy apple tree shown in figure 13. Akron, Colo., November 11, 1914.

The point in question is especially evident in figure 17, where the tendency to make long, slender growth is very conspicuous, in spite of the effort made during the past three or four years to put the tree into the best shape that its condition has permitted.

A study of the illustrations here used emphasizes the fact, which all fruit growers recognize, that the natural habit of growth of different varieties must be considered in intelligent pruning. The upright habit of the Wealthy tree (figs. 13 and 14) and the roundish form of head shown by the Patten (figs. 15 and 16) and the Northwestern trees (fig. 17) make the problem of pruning these two types quite different in each case, even though the principles involved are the same. The Utter tree in figure 8 shows still another type of growth in that, even if left entirely unpruned, the top would not be likely to become as dense as that of the other varieties illustrated, because it does not

branch so profusely. It is therefore less trouble to keep it well pruned, though the principles are the same as in pruning trees of the more profusely branching type.

The manner of pruning other fruit trees does not differ in principle from that followed with apple trees. Ordinarily the tops of plum and cherry trees are not kept quite as open as apples, principally because of the greater natural tendency to form fruit spurs along the branches; but if due attention is not given to the proper forming of the tops when planted and to wise pruning subsequently, the same troubles as those detailed for apples are sure to follow. This fact is made evident by figure 18, showing a native plum tree planted in 1908, as were the older apple trees referred to, which formed a head so dense that it was only with considerable difficulty that the fruit on the interior of the tree could be picked. Figure 19 is a De Soto plum tree that was planted in 1909. This variety does not make naturally as dense a growth as does the one in figure 18; besides, it was planted one year later, so that it began to receive systematic pruning that much earlier in its life. These plum trees have been headed back to some extent during the past three or four years, but they will not be likely to require very much more heading back.



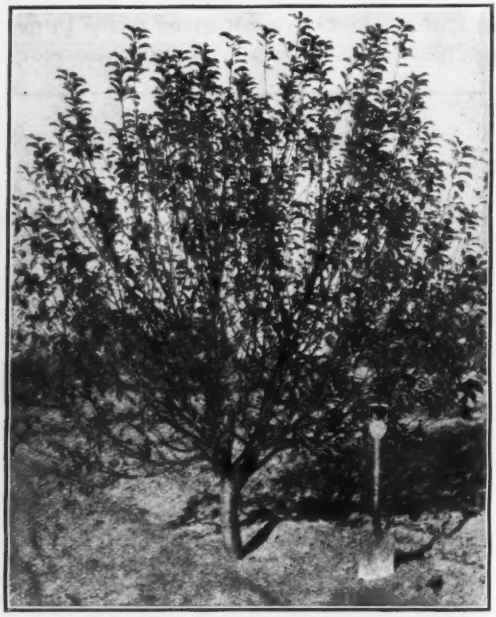
P15961HP

FIG. 16.—The Patten apple tree shown in figure 15 after being pruned. Akron, Colo., November 11, 1914.

The Richmond cherry tree in figure 20 was also planted in 1909. It has responded fairly well to the corrective pruning that it has received during the past three or four years.

Another problem in pruning is suggested by the tree shown in figure 21. In some parts of the Great Plains area rather strong winds blow much of the time. The influence of such winds can be more or less checked as a rule by growing a well-arranged system of

shelter belts that extend across the path of the prevailing winds. A little can be accomplished also by pruning. The branches should be kept well headed in. This heading in may need to be done during the growing season if a long, slender growth is being developed and it is being continuously forced far from its normal position. The top, if kept well opened, will offer less resistance to the wind than where it is allowed to become dense. Besides, if the tops are not too dense the branches will probably be less impeded in resuming their normal positions when the wind is not blowing. However, a complete counteracting of the influence of strong prevailing winds is hardly to be expected except as the force of the winds is broken by shelter belts of some kind.



P18959HP

FIG. 17.—A Northwestern apple tree planted in the spring of 1908, which has received treatment similar to that of the Wealthy apple tree shown in figure 13. This is the largest apple tree in the garden. Akron, Colo., November 11, 1914.

Great emphasis has been placed on pruning with a view to keeping the tops open. There are other reasons why systematic annual pruning should be done. Without regard to the order of relative importance, the more evident reasons may be enumerated as follows:

(1) Every branch is reaching out for sunlight. If the top is sufficiently open so that every leaf receives its full complement of sunshine there is less competition among the different branches than where the top is very dense.

(2) With the decreased struggle for existence among the branches, the crowding of the weaker ones and the resulting dead wood in the top of the tree are largely eliminated.

(3) The development of fruit-bearing spurs well within the center of the tree is encouraged because they receive sunlight, and sunlight in full measure is essential to healthy, vigorous growth.

(4) When a tree reaches bearing age it can be sprayed thoroughly, and it is evident that spraying will be necessary in this area if good fruit is to be

grown. Besides, the fruit can be picked with reasonable ease and comfort. But not so if the picker must crawl through a brush pile to reach it!

(5) The above reasons are common to all fruit-growing regions. Another is of special significance on the Great Plains because of the limited rainfall. The conservation of the moisture in the soil is of the greatest importance. Great quantities of moisture are taken up by a tree and given off through the foliage. In general, the greater the amount of foliage the more rapidly is moisture given off. By proper pruning and thereby the holding of the top to a form or condition as to the number of branches and the amount of foliage which are most consistent with the objects for which the tree is desired, the less will be the loss of moisture from the soil through the foliage. Hence, it follows that wise pruning helps to conserve soil moisture.

FIG. 18.—A plum tree of unknown identity planted in the spring of 1908, which is the largest tree of any kind in the garden, though during 1914 the apple tree shown in figure 17 nearly overtook it. It has received treatment similar to the Wealthy apple tree shown in figure 13, but it is in better shape for a plum than the Wealthy is for an apple. Akron, Colo., November 11, 1914.

IRRIGATION.

While fruit growing on the average ranch in the Great Plains area must be largely under dry-farming methods, a relatively small quantity of water for irrigation may sometimes save fruit trees, and especially strawberries and other small-fruit plants, during a particularly dry period.

Wells of large capacity and windmills are to be found on many ranches and often furnish an adequate supply of water for use in tiding fruits over a crisis of drought. On other ranches a supply of water for emergency use is sometimes stored in earth reservoirs, as suggested in figure 22.

Such a reservoir is made by excavating the earth and mounding it up somewhat about the edge or rim. The inside is then puddled with

clay or in some other way made sufficiently impervious to water to prevent seepage. Obviously, it should be located if possible on a slightly elevated site. It may be filled from the ranch well when the water is not required for other purposes, and the water may be siphoned out when wanted for irrigation.

P18973MP

FIG. 19.—A De Soto plum tree planted in the spring of 1909, which has received treatment similar to the other trees planted prior to 1911, but as its tendency to branch is less pronounced the top never became as dense as some of the other sorts. Akron, Colo., November 12, 1914.

ORCHARD PESTS.

The orchard pests in the Great Plains area are not known to be essentially different from those in other regions except as they are influenced by regional, primarily climatic, conditions.

On account of the comparative dryness of the atmosphere, fungous diseases are not as prevalent as in the humid regions, where conditions are more favorable for their development.

Insects, such as the codling moth and currant worm, may be expected to occur. It may be assumed that the methods of control that are effective in other regions will be equally effective in this area.

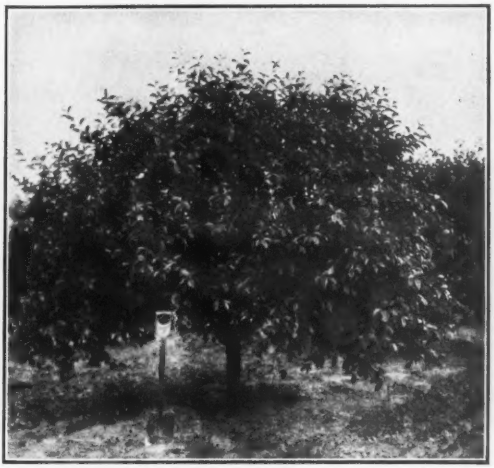
Rabbits are likely to injure young trees during the winter by gnawing the bark, and in some sections pocket gophers and prairie dogs may be troublesome. Information regarding the control of these pests can be obtained by addressing the Department of Agriculture.

Sun scald sometimes occurs during the winter on the south or southwest side of the trunks, especially in the case of high-headed trees. Injuries of this kind can be prevented by shading the trunks

in some way during the winter. Binding laths, narrow strips of board, or cornstalks about the trunks, or even wrapping them with newspapers, will furnish all the protection needed. The material used should be removed in the spring.

HAIL INJURY.

On September 22, 1910, the trees in the Akron fruit garden were seriously injured by a hailstorm. The results may be of interest in connection with the handling of trees in other parts of this area which may be injured by hail. The oldest trees in the garden were completing their third season's growth when the storm occurred. The bark on the north side of the trunks and larger limbs of many of the trees was badly bruised, and in some instances practically torn from the trees. Nearly all varieties of apples and cherries sustained substantially the same degree of injury. There were several varieties of apples, however, that appeared as if by chance to escape in a slight degree, but it is hardly to be assumed that this was due to any greater resistance of these particular sorts to the hail. Most of the plum trees passed through this storm with relatively less injury than that received by the apple, pear, and cherry trees. The tops of the peach trees were practically killed.



P16801HP

FIG. 20.—A Richmond cherry tree planted in the spring of 1909, an example of a tree that did not receive proper pruning and shaping of the top the first two years, but which has responded fairly well to corrective pruning during the past three or four years. Akron, Colo., July 20, 1915.

During the two years following this injury the tops of a good many of the apple trees died, and to some extent those of other kinds also. The seriousness of the wounds on the trunks became very evident. In many instances where the tops were injured beyond recovery, good, strong sprouts developed from some point along the trunks. The one best suited for renewing the top was selected and the original top cut away.

The results which followed such serious hail injury have made it clear that the wiser course as a rule is to dig up and discard trees that show severe damage, especially where they have been planted only two or three years. If they have reached bearing age, or nearly so, it may be worth while to do everything possible to aid the trees in outgrowing the injuries.

P16807HP

FIG. 21.—A Northwestern apple tree planted in the spring of 1911 at the Amarillo Cereal Field Station, Amarillo, Tex., as it appeared on July 23, 1915. The prevailing winds have blown so incessantly as permanently to force the branches to grow largely in one direction, thus making an unsymmetrical top.

During the eight years since this garden was established, the hailstorm that took place on September 22, 1910, is the only one that has caused injury of any consequence in this garden.

FRUIT VARIETIES SUGGESTED FOR PLANTING.

While the cultural methods used in fruit growing in this area have much to do with the measure of success that is attained, they are not more important than the selection of varieties that are adapted to the conditions. In fact, the choosing of the best varieties, especially of the tree fruits, for planting in the different sections of the area is really more of a problem than to determine what methods of culture to adopt. This is true in a measure with regard to every region in which fruits are grown. But where the conditions, as in this area, are especially trying and present at best but a rather narrow margin between possible success and prohibitive limits the problem of varieties becomes especially acute.

As mentioned in the discussion of the climatic conditions, the limited moisture, relatively low temperatures, and, in some parts of the area, a good deal of wind which increases evaporation make a combination of climatic influences that is very trying to fruit trees.

Not all varieties will do equally well throughout the Great Plains. In the southern part of the area the winter temperatures are much milder than they are in the north, but the wind is a more serious factor in the south than in the north. The very low winter temperatures reached in the north make it possible to grow only the fruits that have a high degree of resistance to cold.

While very much yet remains to be determined with reference to the adaptability of varieties to the Great Plains area, it is believed that the mention of a number of different fruits which have been

FIG. 22.—An earth "tank," or reservoir, for irrigating small gardens and fruit plantations. (From Bureau of Plant Industry Circular No. 51, entitled "Fruit Growing for Home Use in the Central and Southern Great Plains.")

planted more or less may be suggestive and of some help to those who are without experience in choosing varieties to plant in this part of the country.

APPLES.

Southern section.—A few of the varieties of apples that may well be considered for the southern part of this area are the Yellow Transparent, Red June, San Jacinto, Maiden Blush, Gravenstein, Wealthy, Grimes, Jonathan, Kinnard, Northwestern, Texas Red, Winesap, Missouri, Arkansas Black, Ralls, and Limbertwig; for crab apples, the Florence and Hyslop. These varieties, named approximately in the order in which they mature, represent a long sequence of ripening, from the early to the long-keeping sorts.

Central section.—Most of the varieties that succeed best in the southern part of the area could doubtless be planted in the central

section. However, the behavior of the fruits in the garden at the Akron Field Station may be used to further the information concerning varieties in this part of the area, at least so far as the growth of the trees is concerned. Reference to the various illustrations in this bulletin showing apple trees in this garden will be of assistance in this connection.

Among the older trees in the garden, the following seem especially promising for this section: Yellow Transparent, Oldenburg, Wealthy, Northwestern, Patten, and the Hyslop crab.

A considerable number of other varieties have been planted during the past three or four years, including the Benoni, Delicious, Eastman, Jonathan, Livland, Longfield, McIntosh, Malinda, Okabena, Peerless, Peter, Plumb Cider, Stayman Winesap, Tolman, Utter, Whitney, and Windsor, and the Dartt, Lyman, Minnesota, and Transcendent crabs, all of which are making excellent growth.

All of these varieties appear to be sufficiently hardy to withstand the normal conditions in this region. But the real test of their value will come later when the trees reach bearing age and because of their larger size the soil-moisture requirements are greatly increased.

A number of dwarf apple trees were planted during the first year or two following the establishment of the garden. These include the Yellow Transparent, Oldenburg, Gravenstein, Wealthy, Bismarck, McIntosh, Esopus, and Northern Spy. Thus far these trees have done well, and their behavior is such as to make them seem rather promising. Dwarf apples can not be recommended for planting, however, until after they have more definitely demonstrated their value.

Northern section.—Naturally the varieties that can be planted in this part of the area must be restricted to the hardier sorts on account of the extremely low winter temperatures. These include the Oldenburg, Wealthy, Hibernal, McMahon, Northwestern, Patten, Malinda, the Hyslop crab, and possibly some others named in the Akron Field Station list for planting where the conditions are not too extreme. There are some localities in this section, however, where even the hardiest sorts would be of doubtful value.

PEARS.

There are hardly enough pears now growing in this area to show the range of their possibilities, unless their comparative absence is to be interpreted as signifying that they are not well adapted to these conditions. The Kieffer, Angouleme (*Duchess*), Bartlett, and possibly one or two other sorts are occasionally grown in the southern part of the area. A variety supposed to be the Warner has grown

well at the Akron Field Station, but trees planted in 1908 have not yet matured fruit. The Flemish (*Flemish Beauty*) is one of the hardiest sorts and sometimes succeeds farther north than most other varieties

PEACHES.

Peach growing in this area is largely confined to the southern section, where a considerable number of varieties are grown to a limited extent. These include the Alexander, Sneed, Triumph, Arp, Carman, Mamie Ross, Chinese Cling, Elberta, Heath, Lee (*General Lee*), Lemon Cling, and others.

At the Akron Field Station peach trees, including a number of the hardier sorts, were killed to the ground, or nearly so, every winter.

PLUMS.

Plums, particularly the native sorts, are perhaps the most dependable of all the tree fruits for planting on the Great Plains. They have been planted quite widely throughout most of this area, and there is a fairly large number of varieties from which one may choose. Of these the following are named, especially for the southern sections: America, De Soto, Golden (*Gold* of Stark Bros.), Hammer, Kroh (*Poole's Pride*), Laire, Pottawattamie, Robinson, Roulette, Six Weeks, Surprise, Wayland, Whitaker, Wildgoose, Wolf, Wooten, and Wyant.

Among the more promising varieties at the Akron Field Station are the following: Brittlewood, Burwood, Cheney, De Soto, Hawkeye, Surprise, Terry, Wolf, and Wyant. The identity of the plum shown in figure 18 is unfortunately unknown, but it is one of the most promising sorts in the Akron garden. It resembles the Brittlewood somewhat and may prove to be that variety. Most of these varieties have been planted widely throughout the Great Plains area. Several varieties of European plums, including the Lombard, Arctic, Shropshire (*Damson*), and others, have also been planted at this station. None of them can be considered promising. The trees make only small growth as a rule, and they do not withstand the winter conditions in a satisfactory manner.

In parts of the northern section the following varieties are more or less grown: Cheney, De Soto, Forest Garden, Rollingstone, Surprise, Wolf, and Wyant.

CHERRIES.

Second only to the plums among the tree fruits for this area are sour cherries. The number of varieties commonly grown is small, the Richmond (*Early Richmond*), Montmorency, and English Morello comprising nearly all the trees that have been planted; in fact,

there are probably to be found many times more trees of a single variety—the Montmorency—than of all the others combined. These varieties are successful generally in the central and southern sections, as well as in some parts of the northern section, but in the latter there are large regions where the conditions practically preclude the growing of cherries.

A Richmond cherry tree planted at the Akron Field Station in 1909 is shown in figure 20. Several trees of the Tartarian and other sweet cherries have also been planted at this station, but they have either died or are in an unsatisfactory condition. It is not believed that sweet cherries are likely to withstand the conditions anywhere in this area.

P11084HP

FIG. 23.—Sand cherries planted in the spring of 1911, fruiting heavily in 1913. Akron, Colo., July 19, 1913.

Sand cherries also do well in many parts of the Great Plains area. The ones shown in figure 23 were planted in 1911 and fruited in 1913. The fruit is of value primarily for making jelly or preserves rather than for use in the fresh state. But as the sand cherry is native to the Great Plains, doubtless selections could be made which would bear fruit of fairly good edible quality.

SAND CHERRY–PLUM HYBRIDS.

Of this type of fruit the Compass cherry, a hybrid between the sand cherry and the Miner plum, is the only variety that has been widely planted as yet in this area. It is proving to be of distinct value. Trees planted at the Akron Field Station in 1910 began bearing in 1912 and produced good crops in 1913 and 1914. Though not of high quality, the fruit is very acceptable. The tree comes into

bearing early and seems to be perfectly hardy here. Figure 24 shows a Compass tree, planted in 1910, as it appeared in November, 1914. The tree makes a very open growth; practically no thinning out of branches has been done in the tree shown here.

A number of other varieties of the same general type have been developed and are now being planted more or less. They are promising for the Great Plains area generally, being very hardy and seemingly well adapted to the conditions under which many other fruits fail. The Opata, Sapa, and Hanska are representative varieties of the new hybrids in this group.

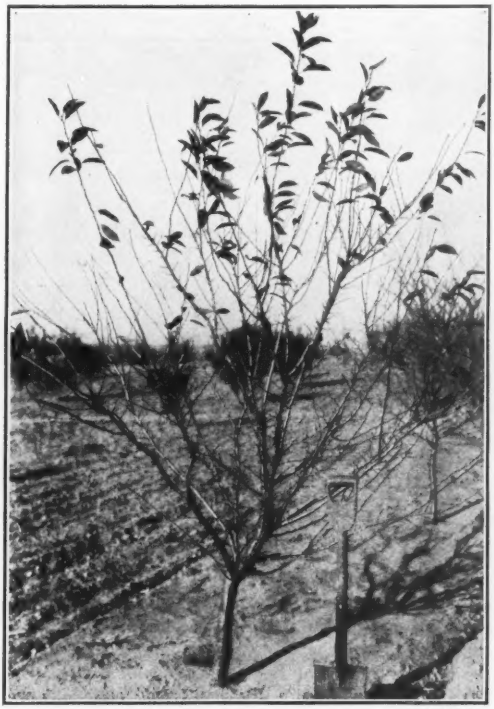


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FIG. 24.—A Compass cherry planted in 1910. The open, spreading habit of growth is to be noted. Akron, Colo., November 11, 1914.

CURRANTS.

Currants appear to be one of the most satisfactory small fruits for the Great Plains. Most varieties do about equally well and are generally hardy. The London (*London Market*) is perhaps grown in larger quantities than any other sort, but the Cherry, Victoria, Red Dutch, and North Star, for red sorts, and the White Grape, for a white variety, have done well at the Akron Field Station and include the sorts most commonly found elsewhere in the Great Plains area.

The plants as a rule are a little slow the first year in getting started, but when well established they make a good growth if properly pruned. Figure 25 shows some currant bushes planted in 1909 or 1910 which are quite typical in growth of all the varieties at the Akron Field Station.

GOOSEBERRIES.

In general, what has been stated regarding currants is true also of gooseberries. They are quite dependable wherever currants are succeeding.

As in the case of the latter, the plants are a little slow in getting established and do not often make a very strong growth the first season. After they are once well established, they appear to be hardy. To keep them vigorous, however, the sprouts that habitually grow from the ground in rather large numbers should be kept well thinned out.

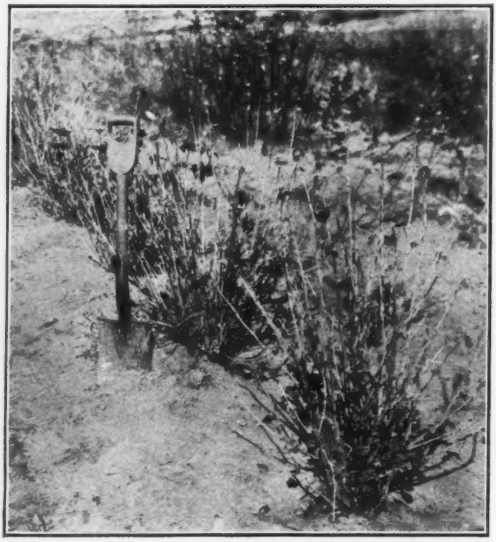

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FIG. 25.—Currant bushes planted about 1910, showing typical growth. Akron, Colo., November 11, 1914.

Probably the Downing, Houghton, and Poorman can be planted generally in this area with as much assurance of satisfaction as any other varieties.

RASPBERRIES, BLACKBERRIES, AND DEWBERRIES.

Raspberries, blackberries, and dewberries have not proved very successful in this area, and they have not been planted as a rule in the ranch fruit gardens. Generally speaking, they do not withstand dry weather well. Even in the humid sections heavy losses sometimes occur as a result of drought.

In many instances in this area the plants are slow in starting growth after being set out, though when once established the roots are quite persistent. The canes, however, are very apt to kill to the ground during the winter. To some extent winter injury can be prevented by bending the canes to the ground and covering them with soil, but how widely this method of winter protection can be used successfully is not definitely known.

Of the varieties observed in this area there seems to be but little, if any, real preference, as there has been no important difference in their behavior. Of the raspberries, the Cuthbert, Loudon, King, and

Sunbeam, for red sorts, and the Cumberland, Kansas, and Winfield, for black varieties, have been planted at the Akron Field Station. They have all borne a little fruit; possibly the Sunbeam has done fully as well as any variety. The canes of all varieties have winter-killed so badly that there is little choice for planting. No winter protection, however, has been given them.

Blackberries at the Akron Field Station have behaved in essentially the same manner as the raspberries. They are rather slow to start into growth after planting. The canes have been killed back to the ground, or nearly so, every winter, and practically no fruit has been produced. The Himalaya—a variety the canes of which are perennial and normally do not die after producing a crop of fruit, as do the ordinary varieties, and which has been considerably exploited for general planting—has made a fairly strong growth each year. However, it is not hardy enough to withstand the winters, though it does not usually kill back as far as do the other sorts. It has produced a very small quantity of fruit, which ripens over a long period, and only a few fruits are ever ripe at the same time, even on 10 or 12 large plants. The berries are small and imperfect, merest nubbins, and the proportion of seed to pulp is so large as to make the fruit almost inedible. Besides the Himalaya, the Snyder, Mersereau, and Rathbun varieties have been planted, none of which seem to be promising for this area.

Only one variety of dewberry, the Lucretia, has been planted. This bore a little fruit in 1912, but in general its behavior has been the same as that of the raspberries and blackberries.

It is probable that much of the winter injury to these fruits is due to the limited moisture supply rather than to the direct effect of low temperatures, especially in the southern and central sections. In the northern part of this area extreme cold is doubtless a limiting factor in itself, except where the plants are adequately protected. To the extent that the difficulty is a matter of moisture, proper irrigation before the ground freezes in the late fall might be of considerable importance.

STRAWBERRIES.

Success with strawberries in this area seems to be more largely a matter of the plants becoming well established and having an adequate moisture supply during certain periods than in the planting of any particular variety; in fact, the establishment of the plants is usually dependent upon a suitable amount of moisture in the soil. The roots are so near the top of the ground, at least until after growth has been well renewed, that they are very susceptible to the surface conditions of the soil. The roots of strawberries may dry out completely before a new growth starts, where other kinds of plants with their roots deeper in the soil would not be seriously affected. Hence, if newly

set plants can be watered as needed until they are well reestablished after transplanting, the chief danger of failure in the beginning is eliminated. Unless this can be done, the plants will die in many cases before a new growth starts.

It is also important that water be available for use during the development of the fruit. At this period the strawberry requires a relatively large quantity of water. If it is lacking, the fruit will be small and much of it may fail to develop.

By mulching with straw during the winter to prevent repeated thawing and freezing as well as to protect the plants from extreme temperatures, strawberries can probably be grown almost anywhere in the Great Plains, provided water can be applied during the critical periods mentioned.

While irrigation might be quite advantageous at times in the growing of other fruits, it may often be practicable to water a small strawberry bed that can be located near the dwelling house, when it would be out of the question to water a fruit garden more or less distant from the buildings.

As to varieties, the Excelsior, Bederwood, Crescent, and Dunlap are suggested. Of these, the Crescent is the only one that has imperfect flowers; it must therefore be planted with a perfect flowering sort in order to produce fruit.

JUNE BERRIES.

Not many June berries have been planted in this area. As a rule they do not make a very vigorous growth, but appear to be hardy when well established and may be expected to bear considerable fruit. The fruit, while not of high quality, will add an agreeable variety for home use.

BUFFALO BERRIES.

Of the wild fruits that are native to this area the buffalo berry is worth consideration, especially for the northern sections, where the range of fruits that can be grown is more limited than in other parts of the area. The fruit is small and quite sharply acid. Its most important use is probably for making jelly, though it is eaten in the fresh state to a limited extent.

The fruit-producing blossoms are borne on separate plants from those that bear the pollen-producing blossoms. As only the former bear fruit, bushes for planting should be largely of that type, though a small proportion of the others must also be planted to supply pollen for the fertilization of the fruit-producing blossoms.

GRAPES.

There is very little definite knowledge concerning the possibilities of grape growing in this area. Low temperatures in the north are

largely prohibitive, but in some parts of the other sections it is probable that a measurable degree of success could be secured, especially in localities where wild grapevines are found. The following varieties, among others, have been tried to a limited extent in this area: Beacon, Beta, Captain, Carman, Concord, Fern Munson, Headlight, Herbemont, Janesville, Lenoir, Marguerite, R. W. Munson. However, no special recommendations or suggestions as to their adaptability to any part of the Great Plains can be made at this time.

MIXED PLANTING ADVISABLE.

Attention should here be called to the fact that many varieties of apples, plums, pears, cherries, and other fruits are more or less sterile with their own pollen. Such varieties, therefore, may be unfruitful, even though they blossom abundantly, unless planted in close proximity to other varieties of the same kind which blossom simultaneously with them. While not all varieties are self-sterile, and sometimes those which are so under certain conditions are not self-sterile under others, the matter is of too great importance to be disregarded when planting orchards or fruit gardens. It is therefore always wise to select at least two varieties of each kind of fruit for planting, unless one has good evidence that under his conditions a variety which he desires is self-fertile.

PUBLICATIONS OF U. S. DEPARTMENT OF AGRICULTURE RELATING TO FRUIT GROWING THAT MAY BE OF USE IN THE GREAT PLAINS AREA.

AVAILABLE FOR FREE DISTRIBUTION.

The Apple and How to Grow It. (Farmers' Bulletin 113.)

The Home Fruit Garden: Preparation and Care. (Farmers' Bulletin 154.)

The Propagation of Plants. (Farmers' Bulletin 157.)

Pruning. (Farmers' Bulletin 181.)

Strawberries. (Farmers' Bulletin 198.)

Raspberries. (Farmers' Bulletin 213.)

Spraying Peaches for the Control of Brown-Rot, Scab, and Curculio. (Farmers' Bulletin 440.)

The information in this bulletin may be applied also to spraying plums and cherries.

Grape Propagation, Pruning, and Training. (Farmers' Bulletin 471.)

The Pear and How to Grow It. (Farmers' Bulletin 482.)

The More Important Insect and Fungous Enemies of the Fruit and Foliage of the Apple. (Farmers' Bulletin 492.)

Growing Peaches: Sites, Propagation, Planting, Tillage, and Maintenance of Soil Fertility. (Farmers' Bulletin 631.)

Growing Peaches: Pruning, Renewal of Tops, Thinning, Interplanted Crops, and Special Practices. (Farmers' Bulletin 632.)

These bulletins on growing peaches (Nos. 631 and 632) are of value in this connection primarily because of the discussions concerning planting, tillage, pruning, etc., which are applicable generally to fruit growing, from the standpoint of the fundamental principles involved.

Blackberry Culture. (Farmers' Bulletin 643.)

Field Mice as Farm and Orchard Pests. (Farmers' Bulletin 670.)

The Roundheaded Apple-Tree Borer. (Farmers' Bulletin 675.)

Cottontail Rabbits in Relation to Trees and Farm Crops. (Farmers' Bulletin 702.)

Bridge Grafting of Fruit Trees. (Farmers' Bulletin 710.)

FOR SALE BY THE SUPERINTENDENT OF DOCUMENTS.

Fruit Growing for Home Use in the Central and Southern Great Plains. (Bureau of Plant Industry Circular 51.) Price 5 cents.

This circular is superseded by the present publication.

WASHINGTON: GOVERNMENT PRINTING OFFICE: 1916

84F

U. S. DEPARTMENT OF AGRICULTURE
FARMERS' BULLETIN No. 727 rev. Oct. 1929

Rev.ed. follows

GROWING FRUIT FOR HOME USE

IN THE GREAT PLAINS AREA

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FRUIT GROWING in the Great Plains area is a home-making rather than a money-making unit in farm-ranch organization. However, anything that adds to the comfort, satisfaction, and well-being of the home often makes returns far in excess of the money value that can be placed upon it. Not all values of material things are money values.

Though the hazards of spring frost, drought, and other climatic factors in this area are too great to justify the planting of any kind of fruit with a view to its becoming a main money crop, there are few seasons when more or less of a yield of some kind—plum, cherry, currant, gooseberry, or other hardy fruit—can not be produced in most sections. An effort to have home-grown fruit every year is very much worth while. Whenever a fruit garden in this area produces a surplus, there need be no fear of an overstocked market to interfere with its ready sale at good prices. Not infrequently ranchers travel many miles to get fruit from some orchard that has developed a commercial surplus.

Although the general methods of fruit culture do not differ greatly in the Great Plains area from those in other sections, there are details of practice of peculiar importance and precautions which if fully observed may help to counteract some of the naturally adverse climatic conditions. The selection of varieties that are the best adapted to these conditions is also fundamental to success.

Washington, D. C.

Issued June, 1916
Revised October, 1929

GROWING FRUIT FOR HOME USE IN THE GREAT PLAINS AREA

By H. P. GOULD, *Pomologist, Office of Horticultural Investigations,* and OLIVER J. GRACE, formerly *Superintendent, United States Dry-Land Field Station, Akron, Colo.*

CONTENTS

	Page		Page
Introduction	1	Proper distances for planting	11
Sites for fruit plantations	3	Tillage	13
Climatic features of the Great Plains	4	Pruning	16
Preparation of the land for planting	6	Irrigation	23
Nursery stock	6	Orchard pests	24
Handling the stock when received from the nursery	8	Hail injury	25
Planting the trees and other nursery stock	9	Fruit varieties suggested for planting	26
		Mixed planting advisable	34

INTRODUCTION

DURING recent years a transformation of large import has been taking place in the Great Plains area. From a vast territory devoted largely to the grazing of cattle and with a very small population it has become an area in which great quantities of grain and other crops are produced annually, with a corresponding increase in the number of homes. Though some sections are still very sparsely settled, the aspect of the entire area has been materially changed by the influx of people who have come from many different parts of the country.

The Great Plains area is not "a natural fruit country," as those regions in which native fruits abound or where the conditions are especially favorable for fruit production are often called. On the other hand, very few native fruits occur in this area, and comparatively little attention has been given to the planting of the cultivated fruits. However, many of the recent comers are from sections where they have been accustomed to grow what fruit was needed for home use. It naturally follows that in many instances upon establishing new homes in this area they have planted a few fruit trees. As a result there are numerous ranches widely distributed throughout the Great Plains where some attempts are being made to grow a home supply of fruit.

NOTE.—This bulletin is intended especially for those in the Great Plains area who are interested in growing fruit for home use, but some parts of it, especially the discussion about pruning and shaping trees, are of general interest to people living in other sections of the country.

The information is based largely upon the results obtained in a dry-land fruit garden which was established in 1908 at the Dry-Land Agriculture Field Station of the Bureau of Plant Industry, Akron, Colo. Most of the illustrations are from photographs taken in this garden.

This bulletin supersedes Bureau of Plant Industry Circular No. 51, entitled "Fruit Growing for Home Use in the Central and Southern Great Plains."

In a few instances orchards of some commercial importance have been developed. Most of these are the outgrowth of one or more of several conditions: (1) The location has proved to be exceptionally well suited to the growing of fruit; (2) the owner has had considerable experience in fruit growing before coming to this section; or (3) the owner, as he has gained experience here with a small orchard, has found himself better qualified for the details of fruit raising than the ranchers generally, and has gradually increased his fruit interests to good advantage.

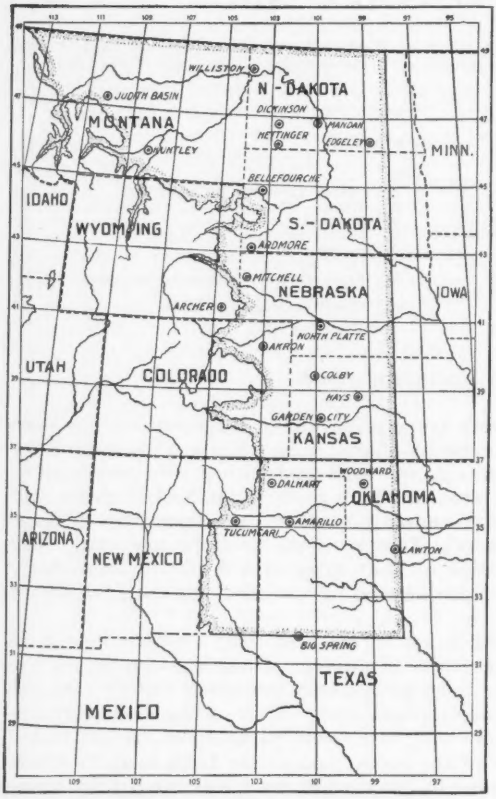

FIG. 1.—Sketch map of the Great Plains area, which includes parts of 10 States and consists of about 400,000 square miles of territory. Its western boundary is indicated by the 5,000-foot contour. Each dot within a circle (⊙) indicates the location of a field station of the Office of Dry-Land Agriculture Investigations of the Bureau of Plant Industry

The surplus fruit from the home orchards, as well as that produced in those of larger size, always finds a ready sale, buyers sometimes driving many miles to obtain it.

Within the boundaries of the Great Plains area there are a few restricted districts that are under irrigation. In some of these, orchard interests of considerable commercial importance have been developed. These interests are not discussed, however, in this bulletin.

The tree fruits that occur most commonly in the dry-land ranch orchards are apples, cherries, and native plums. In some of the milder parts of the area, especially in the southern section, pears and peaches are more or less common, while still less frequently apricots are found. Currants and gooseberries are probably the most important as well as the most common of the small fruits. June berries, buffalo berries, and strawberries are sometimes to be found.

The successes and failures in this area, as in other sections, are very largely dependent upon the care and attention given by the

owner. In certain regions, however, it is difficult to succeed, whereas in others a complete fruit failure is comparatively rare. The one controlling factor in the Great Plains area, outside of those sections where water for irrigation is available, is the lack of moisture, yet after the trees have become well established it is not often that this causes more than temporary loss, such as a crop of fruit for a single season.

In some sections winds and hailstorms occasionally cause damage, but these losses are not more frequent with fruits than with the field crops. However, the trees sometimes suffer permanent damage from hailstones, even being killed in some cases.

The majority of the settlers on the Great Plains must depend upon their own plantations for a supply of fruit for home use. Most of those who do not have home-grown fruit are obliged to do without it. The chief interest, therefore, in the cultivation of fruit in this area centers about the home and the production of enough to meet the needs or desires of each family. In other words, fruit growing here is a home-making rather than a money-making enterprise.

The geographical position and extent of the Great Plains area are shown in Figure 1. Its western boundary, as indicated, is the 5,000-foot contour; its eastern boundary is arbitrarily placed at the ninety-eighth meridian.

SITES FOR FRUIT PLANTATIONS

Probably the greatest obstacle, either directly or indirectly, to the successful growing of fruit in the Great Plains area is lack of moisture in the soil. It follows, therefore, that the site for an orchard or small fruit garden should be selected with a view to securing the maximum supply of soil moisture. In many instances, particularly on the smaller ranches, the conditions are so nearly uniform that there is no choice in this respect. The convenience of the site with regard to the buildings will usually be the ruling factor in such cases.

But on many ranches there are sites that are more favorable for fruits than others on account of the soil-moisture factor; for instance, where a small stream or arroyo passes through the ranch it may furnish an additional supply of water. In some cases the topography is such that a reservoir can be made by building a small dam across the stream and diverting the water to the orchard. Not infrequently some of the larger streams that pass through this area have an underflow that extends some distance on either side. Where this condition prevails and the underflow is reached by their roots, the trees often make a remarkable growth.

Again, there are many instances where the lay of the land is such as to result in a large amount of run-off during heavy rains. If this run-off, which would otherwise be lost, can be collected in small contour ditches and distributed where fruits are planted, a considerable increase in the supply of moisture is secured. Sites for fruit plantings can be selected sometimes with reference to this possibility. Advantage should be taken of every factor which will increase or conserve the supply of moisture in the soil.

CLIMATIC FEATURES OF THE GREAT PLAINS

The climate of the Great Plains has been classified as semiarid. It may be better to say that it is variable. One season may have almost humid and another almost arid conditions. The mean annual precipitation is relatively low. Years of relatively high precipitation may be followed by years of relatively low precipitation. Other climatic factors usually correspond with the rainfall. In a year of relatively high rainfall there will be a lower rate of evaporation and higher humidity than in a year of low rainfall.

Another climatic factor of much importance in crop production on the Plains is the distribution of the rainfall. This is probably more important in crop production than the amount of annual rainfall. A relatively low rainfall, properly distributed, may produce a crop where a much higher rainfall, unfavorably distributed, may accompany a crop failure.

TABLE 1.—*Annual and seasonal precipitation and seasonal evaporation at 14 stations in the Great Plains area*[1]

Station	Altitude (feet)[2]	Precipitation (inches)[3]						Seasonal evaporation (inches)[3]		
		Annual			Seasonal					
		Minimum	Maximum	Average	Minimum	Maximum	Average	Minimum	Maximum	Average
Judith Basin	4,228	14.96	23.78	18.06	7.04	17.21	9.34	22.012	29.353	24.491
Huntley	3,000	11.92	11.92	11.92	5.92	6.02	5.79	23.754	24.214	23.984
Williston	1,875	10.28	18.99	14.84	4.75	14.49	9.66	20.422	26.877	24.216
Dickinson	2,543	11.93	21.22	16.69	6.85	16.28	9.79	20.673	25.745	23.919
Edgeley	1,468	11.94	21.95	16.71	7.85	14.98	10.11	18.663	24.893	21.866
Hettinger	2,253	12.72	15.68	14.20	8.92	12.47	10.36	21.539	28.239	24.639
Belle Fourche	2,950	6.64	17.73	13.11	4.08	9.78	6.90	26.472	33.750	28.794
Scottsbluff	3,950	13.77	18.51	16.14	2.53	8.52	4.69	23.804	29.381	26.081
North Platte	3,000	11.18	23.01	18.05	6.85	12.36	9.45	28.445	38.168	32.359
Akron	4,600	14.51	22.46	18.28	6.42	13.86	9.02	26.064	35.654	31.420
Hays	2,050	15.59	27.80	21.30	8.18	17.97	11.17	30.625	44.373	35.790
Garden City	2,900	11.82	23.58	18.54	2.79	14.43	8.65	34.325	43.510	38.185
Dalhart	4,000	13.69	16.35	15.11	5.09	9.85	8.01	35.459	41.748	38.988
Amarillo	3,676	10.69	27.80	18.28	6.17	11.38	9.13	33.804	42.076	36.724

[1] The period of time covered by the investigations made at the several stations ranged from two to eight years, depending upon the time when the different stations were established, the same period being covered by the data regarding precipitation and evaporation shown here.

[2] The altitude given is based in most cases on that of the nearest town.

[3] The records of annual precipitation for 1914 are not included. The records of seasonal precipitation and evaporation for 1914 are included for all stations, being figured from May 1 to Sept. 1. Evaporation measurements are made from a free water surface, in a tank sunk into the soil to almost its full depth. The water surface is kept about level with the surface of the ground

Table 1 gives the maximum, minimum, and average annual precipitation and the seasonal maximum, minimum, and average precipitation and evaporation of the Great Plains area. By seasonal is meant the period between the average time of seeding and the average time of harvest. * * *

Figure 2 shows the earliest and latest dates of the last killing frost in the spring, the earliest and latest dates of the first killing frost in the fall, and the average length of the frost-free period at each station. Each hatched horizontal bar represents the period between the average dates of the last killing frost in the spring and the first killing frost in the fall. The number of days in the average frost-free period for the station is shown in the figures above the bar. The solid-line curve at the left shows the earliest date at which the frost-free period has begun. The broken-line curve at the left represents the latest date at which the last killing frost of the spring has occurred. The solid-line curve at the right represents the earliest date and the broken-line curve at the right the latest date at which the first killing frost of the fall has occurred.

This diagram [fig. 2] shows clearly the increase in the length of the frost-free period from the north to the south. The shortest average period is 100 days, at Hettinger, and the longest 194 days, at Amarillo.[1]

[1] See Chilcott, E. C., Cole, J. S., and Burr, W. W., "Crop production in the Great Plains area: Relation of cultural methods to yields," U. S. Dept. Agr. Bul. 268, pp. 3–4, fig. 2. 1915.

In the Great Plains area the regional restrictions to fruit growing, so far as the natural conditions are concerned, are primarily factors of temperature and moisture.

In some sections of this area, especially the northern part, fruits for planting must be selected with a view to their hardiness and their ability to endure extremely low temperatures in winter. But throughout the Great Plains area as a whole unseasonable frosts during the blossoming period or at other critical stages of growth more often cause damage than extreme cold during the dormant period. However, the combination of relatively low winter temperatures, limited moisture supply, and drying winds that sometimes prevail is extremely trying on most fruit trees and may cause serious damage where any one or even two of these factors operating at the same time would not adversely affect the trees.

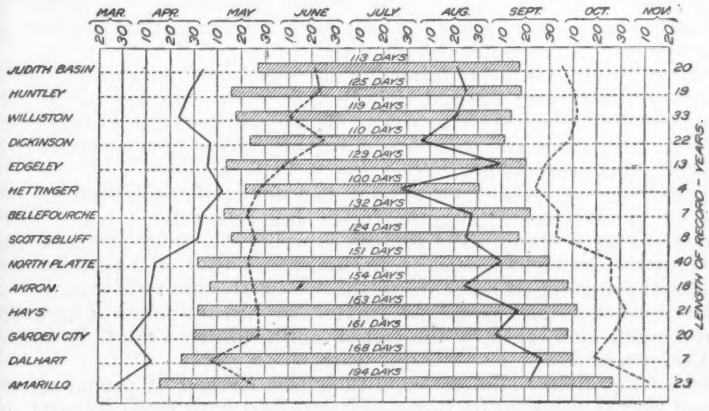

FIG 2.—Diagram showing the average frost-free periods and the earliest and the latest dates at which the last killing frost in the spring and the first killing frost in the fall has occurred at 14 stations in the Great Plains area

The general climatic features of this area are well indicated in the paragraphs above quoted. In that connection the statements are applied to the production of general agricultural crops, but they are none the less applicable to fruit growing.

Another climatic factor that occasionally does great damage is hail. Trees of considerable size are sometimes completely killed or so badly bruised or otherwise injured as to render them worthless. Hailstorms occur much more frequently in some parts of this area than in others. In sections where they are known to be severe, the planting of fruits is likely to prove disappointing.

Some sections of the Great Plains are further characterized by winds which blow almost continuously. While the wind may not be a prohibitive factor in the growing of fruit in any section it is a serious one where it blows much of the time. It not only results in the premature dropping of the fruit, but it becomes practically impossible to prevent the tops of the trees from growing very much to one side.

PREPARATION OF THE LAND FOR PLANTING

For fruits, land that has been in cultivation for one season or for a sufficient length of time for the sod to have become thoroughly rotted is very much to be preferred to newly broken land.

The planting of fruits in this area should be done as a rule in the spring, and in any special preparation that may be made the aim should be to handle the soil so that it will contain as much moisture as possible at the time the planting is done.

In seasons of fairly abundant precipitation, especially if there is considerable rainfall or fairly heavy snows during the winter, there may be enough moisture stored in the soil in the spring to insure the starting of the trees, even if a crop has been produced the previous season. But because of the wide seasonal variation in the amount of precipitation, frequently falling far below normal, and the importance of an abundant supply of soil moisture in the spring at planting time, it is generally advisable to summer-fallow during the season that precedes the planting.

In addition to summer fallowing, an adequate supply of soil moisture is still further insured if deep furrows are opened in the fall along the lines of the tree rows. These will serve to collect both the drifting snow and some of the run-off during heavy rains which might otherwise be lost.

One very successful fruit grower on a dry-land ranch even supplements the furrows by digging in the fall rather large holes where the trees are to stand. The run-off, as well as the snow caught in the furrows, will tend to settle in the holes and thus still further augment the amount of moisture in the soil in the immediate radius of the trees. In some cases, cross furrows or furrows made at an angle to the direction taken by the run-off and leading to the holes might also be useful.

Under ordinary climatic conditions this method of preparing the land should result in its being well supplied with moisture, and the trees should start into growth readily and make a good development of roots so far as the soil moisture is concerned.

NURSERY STOCK

In the central portion of the Great Plains area, as represented by the United States Dry-Land Field Station, Akron, Colo. (fig. 1), the most favorable period for planting is usually the last of April and early in May. It varies in other parts of the area from earlier in the southern section to somewhat later farther north. Normally, nursery stock is delivered in the spring rather than in the autumn. It is absolutely essential for success that it reach its destination in a perfectly dormant condition. Hence, it follows that while it may be satisfactory for those ordering stock for planting in the southern part of the area to secure it from northern sources, it is not well to obtain it from the south for planting in the northern sections, on account of the fact that the buds may start on stock from the south before the most favorable period for planting in the north has arrived.

On account of the arid or semiarid conditions of this region the period following the planting of the trees is very trying unless there

is a sufficient supply of moisture stored in the soil and available for their use. The moisture in the trees is being dried out constantly, and more rapidly than would be the case in a humid region. The roots of newly planted trees do not at first readily take up moisture from the soil, and if it is excessively dry the trees may die before they can start into growth. Because of these moisture factors it is of the greatest importance to procure only trees and other nursery stock which are most likely to start into growth readily and quickly when planted.

In many fruit-growing regions apple, pear, plum, and cherry trees are commonly planted when 2 years old; that is, after they have made two seasons' growth in the nursery from the bud or graft. However, in some commercial apple and cherry growing sections there is a strong sentiment in favor of 1-year-old trees for planting in preference to older ones. The younger trees have an advantage in that it is possible to form the tops at any desired height. The heads are already formed on 2-year-old trees when received. Not infrequently the trees have been headed too high to be desirable, and it is not always possible or practicable to plant such trees deep enough to overcome this objection. And, again, good, strong 1-year-old trees, as a rule, withstand transplanting fully as well as older trees; they are lighter to handle in shipping and in other ways are more desirable. This is true of other trees as well as of apples and cherries.

Inexperienced buyers of fruit trees not infrequently measure the value and grade of the trees delivered by their size; the larger the tree the better it is supposed to be. But experience has proved that thrifty, medium-sized trees are better for planting in the Great Plains area than larger ones, with a preference for good, strong 1-year-old trees. The larger 2-year-old trees as a rule do not withstand transplanting as well, nor are they as likely to live and make a good growth as the medium-sized ones of the same age.

On the other hand, a very radical distinction must be made between medium-sized or relatively small healthy trees and those which are small because they have been stunted by some adverse condition. Weak, stunted trees should be refused absolutely. They are likely to be expensive even as a gift.

Good root systems are also of special importance in satisfactorily starting trees planted under the conditions which normally prevail in this area. In sections where all the factors influencing growth are favorable, the difficulties incident to poor roots, if not too serious, may be overcome perhaps without permanently harmful results; but in the region under consideration well-developed and abundant root systems are especially important. If the roots of trees consist of only a very few large parts, new growth does not start as readily and as quickly as it does if the plants are well provided with a large number of small roots.

But here again caution is necessary. A large mass of very fine threadlike roots is due cause for suspicion. Such roots may indicate a disease known as hairy-root, a form of crown gall. Although there is a wide difference of opinion and experience concerning the seriousness of this trouble, it is by far the safer plan to discard trees so

affected; the roots in any event are abnormal and if planted there is always the possibility that the trouble will develop to such an extent as to affect seriously the vigor and durability of the tree. All trees and vines showing crown gall or abnormal growths of any kind should be rejected.

The height of the tree is as important as its root system. Trees that have been headed from 1½ to 2½ feet high as a rule start into growth more readily and develop better than trees headed 3 to 3½ feet high. In a large majority of cases the high-headed trees, even when they live, make only a very small growth the first season and rarely develop well-formed, satisfactory tops as they increase in age.

HANDLING THE STOCK WHEN RECEIVED FROM THE NURSERY

It has already been stated that planting in the spring rather than in the fall is to be advised in this area. To insure the timely arrival of the stock from the nursery it is wise to order it shipped with a view to its arriving at its destination a little in advance of the actual date of planting. Otherwise, an unexpected delay in shipping or during transit may result in inconvenience or in the undue starting into growth of the stock before it is received.

To hold trees and other plants in good condition until planted, they should be unpacked immediately upon arrival and heeled in without delay in a well-drained spot. The heeling in is accomplished by digging a trench 12 or 15 inches deep, sloping on one side. The roots are placed in the trench, the trunks of the trees lying at right angles to it on the sloping side. The position is illustrated in Figure 3. In case the trees are tied in bundles when received they should be separated; otherwise, the roots can not be properly protected. Moist, finely pulverized soil should then be worked thoroughly in among the roots, completely filling all the spaces, and the roots finally covered several inches deep.

If it is necessary for any reason to have the trees heeled in for a long time before they are planted, it may be advisable to cover the tops, entirely or nearly so, with soil, to prevent the sap from being dried out to an undue extent. With the first advent of warm weather, however, the branches should be uncovered.

The soil that is placed over the roots and such other parts of the trees as may be covered should be packed very firmly. This is not only for the purpose of excluding as much air as possible, but to lessen the danger of mice finding a harbor among the trees, where they might cause injury by gnawing the bark.

Trees that are heeled in should be examined frequently, with especial reference to moisture conditions. While the soil about the roots should not be kept in a water-soaked condition, it should not be permitted, on the other hand, to become thoroughly dry. The sap in the trees would be likely to dry out and the bark shrivel if this should occur. Difficulties of this sort can be avoided easily by the judicious application of water.

Berry bushes and other small fruits are handled in essentially the same manner as trees, but the trenches in which the roots are placed are shallower than for tree fruits, to correspond with the size of the plants.

PLANTING THE TREES AND OTHER NURSERY STOCK

The most satisfactory time for planting fruit trees and bushes in eastern Colorado in the average season is the last of April or the first of May. The soil is usually in good workable condition at this time, and as a rule it is a period during which there is considerable precipitation. These conditions are favorable for growth, and if a tree or other plant reestablishes itself readily in its new place and growth begins promptly one of its most critical periods is past.

The best time for planting fruits in the other parts of the Great Plains area may vary somewhat from the dates for Colorado given above. Generally, it may be done earlier in the southern sections and later in the north. It should be done after the danger of hard

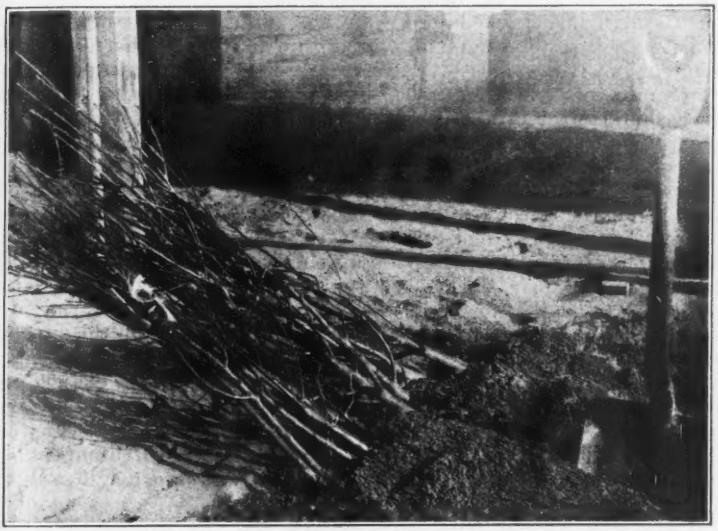

FIG. 3.—Peach trees heeled in. The position in which the trees are placed is to be noted

freezing temperatures is past and when the soil is in good condition for working.

The method of planting fruit trees in this area does not differ in any essential from that commonly followed in other parts of the country. In handling the trees every possible precaution needs to be taken to prevent the roots from becoming dry when the trees are removed from place to place. The roots should not be exposed to the air more than is absolutely necessary. Covering with wet burlap is, perhaps, the most convenient means of giving protection, but wet chopped straw, damp moss, or other materials that can be moistened and covered over the roots may be made to serve the purpose; or the roots may be protected by puddling them. This consists merely in dipping the roots in a puddle of clay. The clay should be of such consistency that a thin layer of mud will adhere to the roots when they are dipped into it and at the same time per-

mit them to be moved about in it with perfect ease and freedom. Such a coating of mud will afford considerable protection against undue drying out from exposure to sun and wind. By observing this precaution at all times, including the period of exposure incident to planting the trees, there should be no loss due to dried-out roots.

The holes are made broad enough to receive the roots without bending them from their natural position and deep enough so that when filled even with the surrounding surface the trees will stand 2 or 3 inches deeper than they did in the nursery. Sometimes the holes are made in the fall, as previously described.

Before planting, the ends of all broken roots and roots otherwise injured should be removed with a smooth cut. As the trees are placed in position in the holes the soil is carefully worked around the roots and firmly packed by tramping. If the soil is moderately moist it will not be necessary as a rule to water the trees when planted; but if the soil is dry it may be well to pour a pail or two of water into the hole after it has been partially filled with soil, and then complete the filling after the water has soaked in. The subsequent use of water should be governed by conditions. If it continues dry after the trees are planted an occasional application of water sufficient to keep the soil in the vicinity of the roots well moistened may enable the trees to grow readily when otherwise they might fail entirely from lack of moisture.

When the trees are planted they should be headed back to the desired height. It is believed from experience and observations under Great Plains conditions that the main stem or trunk of the tree should not exceed 2 or 2½ feet in height, measuring from the surface of the ground after the tree is planted. In many cases the heads may well be formed even lower than this. Trees with low heads are not as likely to be injured by sun scald as those with high heads, nor are they as much affected by the wind. If the trees have been headed in the nursery, as is the case with stock 2 years old, it is often impossible to handle them so as to place the heads at the desired height. With 1-year-old trees this difficulty does not exist.

There is a wide difference of opinion and practice among fruit growers as to the details to be observed in shaping the permanent head of the tree, but the conditions attending tree growth in this area are such that it is believed an open head which develops from a few main branches is preferable to one so managed that it becomes dense and bushy.

To develop an open head, only four to six branches should be left when the tree is pruned at the time it is planted, or when it is formed later if 1-year-old trees have been used. These branches should be selected with a view to their position on the trunk. They should be arranged symmetrically and spirally about the trunk and should start from different levels, thus leaving some space vertically between the different limbs. If two limbs branch from the trunk at the same level there is much more danger that they will split down in later years under the weight of a large crop of fruit or during a heavy wind than where the formation is as here suggested.

The branches selected for the permanent top of a 2-year-old tree should be cut back considerably at the time the tree is planted. If the

tree has made a fairly vigorous growth in the nursery the preceding season, one-half or two-thirds of the length, as a rule, may be cut away. This will tend to make the branches strong and stocky rather than slender and "leggy," as when no cutting back is done.

This plan of forming the head also reduces the number of branches which the roots are required to supply with moisture during the first season's growth. It should be kept in mind that a considerable portion of the root system is lost in digging the tree from the nursery and that the branches need to be reduced proportionally.

The plan described is illustrated in Figure 4 and still further shown in Figures 5 to 10. Figure 4 shows a McIntosh apple tree in July of its second season's growth in the Akron fruit garden. It was headed low, the number of permanent branches was reduced to four or five, and from the very beginning the top has been kept open. The same plan of development may be seen in the other illustrations mentioned.

FIG. 4.—A McIntosh apple tree in July of its second season's growth, which has been pruned with a view to developing an open head. Akron, Colo., July 19, 1913

The method followed in planting small fruits is essentially the same as that described for tree fruits. They are planted, as a rule, a little deeper than they were originally. They are cut back, if necessary, to make the tops correspond to the root system, and in other respects the directions given above are readily adapted to handling small-fruit plants.

Because the roots of small fruits are nearer the surface than those of tree fruits it may be necessary to give more attention to watering newly set plants until after they start into growth than is suggested for trees. This applies with special emphasis to strawberries.

PROPER DISTANCES FOR PLANTING

The distance between fruit trees is a matter of greater importance than is commonly realized. The space unoccupied at the time the small trees are planted seems out of proportion to their size, but the

requirements when the trees are mature must be anticipated. It should be remarked that the roots extend very much farther than the spread of the branches, contrary to a commonly expressed notion. At Cheyenne Wells, Colo., the roots of a 14-year-old apple tree were traced 26 feet in one direction from the tree and some 9 or 10 feet in the opposite direction, making a spread of at least 35 feet; in fact, the actual spread was several feet more than this, as it became impracticable to trace the roots in the very dry, hard soil to their ends.[2] The great number of roots that develop on apple trees under semi-arid conditions is suggested by Figure 11, and the expanse of the roots is shown in Figure 12. It was 26 feet from the stump to the

FIG. 5.—A Delicious apple tree after two seasons' growth as it appeared before its annual pruning. The foundation for the top consists of four or five main limbs

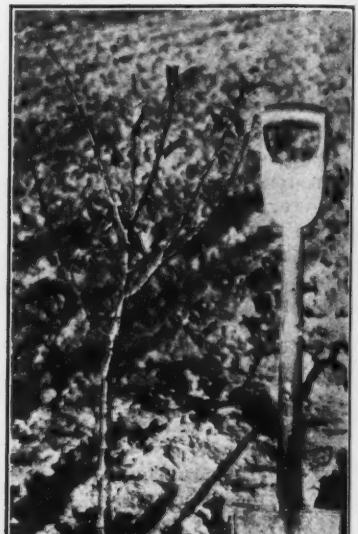

FIG. 6.—The Delicious apple tree shown in Figure 5 after being pruned. Both figures were reproduced from photographs taken at Akron, Colo., November 12, 1914

end of the root held by the man shown on the left in the illustration (fig. 12).

It therefore appears that trees in their earlier life may suffer more from the crowding of the roots than from the crowding of their tops. The bearing which these facts have on the welfare of the trees is largely in relation to the moisture supply. If the trees are too close together their combined moisture requirements may exceed that furnished by normal precipitation.

[2] This study of the root systems was made in August, 1910, at the Dry-Land Substation of the Colorado Agricultural Experiment Station by J. E. Payne, then connected with that station, and one of the writers. For further details, see Payne, J. E., "Notes on a dry-land orchard," Colo. Agr. Exp. Sta. Bul. 173. 1910.

Too close planting is a common fault in many of the commercial fruit-growing districts in irrigated as well as in humid sections. Its results in semiarid sections where irrigation is not practiced are likely to be particularly serious.

Although fruit trees may not grow as large under the semiarid conditions of the Great Plains as in humid sections, it is not believed that this fact is sufficient to warrant close planting. On the other hand, the size attained here by trees is likely to be governed very largely by the amount of moisture available.

FIG. 7.—The same Delicious apple tree shown in Figures 5 and 6 as it appeared in July of the following season. The buds near the ends of the stubs in Figure 6 have developed into branches, thus making a good framework for the development in the future of a strong, well-branched tree. Akron, Colo., July 21, 1915

In the light of the foregoing statements, the following distances each way for the planting of different fruits are suggested:

Apples, 30 to 35 feet.
Pears, 25 to 30 feet.
Peaches, 20 to 25 feet.
Plums, 20 to 25 feet.
Cherries, 20 to 25 feet.
Sand cherry-plum hybrids, 10 to 15 feet.
Currants, 5 to 6 feet.
Gooseberries, 5 to 6 feet.
Raspberries, 6 to 7 feet.
Blackberries, 6 to 7 feet.
Strawberries, usually in rows 3 or 3½ feet apart, with the plants 1½ to 2 feet apart in the row.

Many of these distances may seem excessive at first, but they allow none too much space when the demands of mature trees and other plants for moisture and plant food are taken into account.

TILLAGE

The tillage (or cultivation, as it is more commonly termed) of a fruit garden or orchard in this region should be very thorough. Its primary objects are to maintain the surface of the soil in a fine granular condition, so that it will readily absorb all of the rainfall, and to prevent the growth of weeds. A fine dust mulch does not take up the moisture as freely as a granular surface does.

The other objects of tillage will generally follow as a matter of course. Usually it should be continued fairly late in the season.

In 1910 the seasonal cultivation in the dry-land ranch garden at Akron was discontinued early in August. This was done in order to avoid further stimulation of growth and to insure a thorough ripening of the wood before the advent of cold weather. However, no beneficial results followed that could be attributed to the cessation of cultivation as early as this; and, besides, it might prove a rather hazardous plan in some seasons. The growth of weeds following the cessation of cultivation so early in the season was sufficient to make a serious drain on the supply of soil moisture. The danger lies in the fact that the moisture in the soil might be reduced

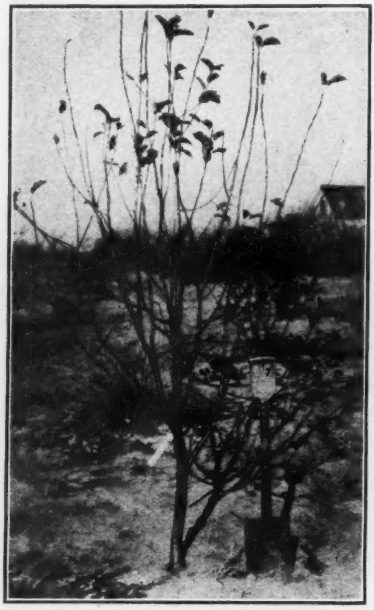

FIG. 8.—An Utter apple tree after its third season's growth as it appeared before its annual pruning. In previous years the pruning has been directed toward keeping the top open

FIG. 9.—The Utter apple tree shown in Figure 8 after being pruned. Both illustrations (Figs. 8 and 9) were reproduced from photographs taken at Akron, Colo., November 11, 1914

to such an extent that the trees would suffer during the winter or the following season in case there was little precipitation.

Tillage in the garden at the United States Dry-Land Field Station has been frequent enough to destroy weeds before they have made any considerable growth, to prevent the soil from blowing, and to insure against any run-off during heavy showers. To these ends the surface has been kept in a rough, granular condition. In accomplishing these objects, the soil moisture has been well conserved against evaporation from the surface. Tillage has usually been continued until the latter part of August, or late enough to prevent any considerable growth of weeds and to avoid all danger of their going to seed.

This practice with regard to tillage has given good results in the Akron garden. Moreover, in its general principles it has been followed by ranchers in other sections of this area in the successful growing of fruit. Slight modifications of this plan of tillage may be necessary under some soil and climatic conditions, but it is believed that it embodies the essential features, so far as this operation is concerned, in maintaining orchards and fruit gardens in this area, not only while they are young but after they reach maturity.

Clean tillage throughout the season during the early life of an orchard amounts practically to summer fallowing. During the first three or four years and before the roots have extended very far, the demands made by the trees upon the soil moisture are comparatively small. With normal precipitation the tendency obviously would be for the percentage of soil moisture in the spaces between the trees to increase rather than to decrease under this method of management. In this way, the greater demands of the trees for moisture as they reach larger size are anticipated in a measure, at least for a time.

FIG. 10.—The same Utter apple tree shown in Figures 8 and 9 as it appeared in July of the following year. Akron, Colo., July 21, 1915

Cover crops and green-manure crops serve a most important purpose in maintaining the fertility of orchard soil in humid and irrigated sections, but in this area where the soil moisture is so largely the limiting factor their use rarely, if ever, can be advised. The growing of these crops usually would draw so heavily upon the moisture in the soil that they would be a menace rather than a benefit to the fruit. The humus furnished by such crops in sections where they can be grown must be supplied here by applying manure or vegetable matter in some other form.

For a similar reason the interplanting of crops between the rows of trees in young orchards, as is commonly done in commercial fruit-

growing sections, can not be recommended in this area. In the case of apple trees planted 30 or 35 feet apart, a row or two of corn or some vegetable possibly could be planted for the first two or three years midway between the rows of trees without irreparable harm to the latter, but the wisdom of even this limited competition with the trees would usually be doubtful.

The tools used in cultivating fruits may be a disk harrow, corn cultivator, or shovel cultivator, as conditions or convenience may dictate. While there are specially constructed orchard-tillage implements, the same tools used in the cultivation of general crops may be used advantageously in most cases.

FIG. 11.—Part of the root system of a 14-year-old Ben Davis apple tree. Colorado Experiment Station, Plains Substation, Cheyenne Wells, Colo., August 11, 1910

PRUNING

There is probably no phase of fruit growing on the Great Plains which requires greater care and attention in order to obtain the best results than the operation of pruning. Although this is especially true of tree fruits it is also of importance with small fruits.

One of the commonest faults to be found with fruit trees on many ranches in the Great Plains area is the density of the tops. This fault, however, is not more characteristic of fruit growing in this area than it is in many other parts of the country. It is a natural consequence in the first place of planting trees without properly forming the heads at the time they are set out and of improper pruning or no pruning at all in after years. In fact, as will be illustrated later, it is often practically impossible to correct the faults incident to improper pruning at the time of planting by pruning when the trees are several years old.

If only a single idea were to be kept in mind in pruning a fruit tree throughout its life, that idea might well be to keep the top sufficiently open to admit air and sunshine freely. If this is accomplished, most of the other objects for which fruit trees should be pruned will also be realized.

The fear that the branches will be injured by exposure to the sun is frequently offered as a reason for allowing the tops to become very dense. It is true that where a large limb which has been shaded continually is suddenly exposed to the direct rays of the sun serious injury may result, but when a tree is grown from the beginning with an open head and is properly pruned there is little danger from this cause.

In further understanding the principles of pruning, the reader will be assisted by reference to the accompanying illustrations, most

FIG. 12.—The same stump of a Ben Davis apple tree shown in Figure 11. The roots were traced a distance of 26 feet on the left and 9 or 10 feet on the right. The small extremities of the roots, amounting probably to several feet in length, still remained in the soil

of which are made from photographs taken in the Akron fruit garden.

Figure 4, previously referred to in connection with the planting of trees, shows also the pruning which was done following the first season's growth. The limbs were cut back to the points just below the level of the upper part of the spade handle, where the secondary branching may be seen. Branches which may have crossed each other and other superfluous growth were also cut out. While the top is open, it will be observed that the main limbs are well protected by leaves that developed from short spurs or buds. In a very dense top there would be but little development of leaf-bearing spurs along these limbs. The photograph reproduced here was taken in July, 1913. A good, strong current season's growth is evident. This growth would normally be headed back during the dormant season following the growth made in 1914, and such thinning out as might seem necessary to maintain the top in a well-opened condition would be done at the same time.

Figure 5 shows a Delicious apple tree that was planted in the spring of 1913. The top was lightly pruned in July of that year, the superfluous branches being removed. This figure shows the tree as it looked in November, 1914. The current season's growth of some of the branches was 2 to 3 feet, with practically no side branches. Figure 6 shows the same tree after it had been pruned. The results of this heavy heading back in November, 1914, become apparent by reference to Figure 7, which shows the same tree in July, 1915; that is, during the middle of the following season's growth.

The strongest growth has taken place from buds near the ends of the stubs of branches shown in Figure 6. This is resulting in a well-proportioned stocky tree, yet one which can be kept well opened to the air and sunshine with a minimum amount of pruning. Had this tree been left, as shown in Figure 5, without heading back, the branching during 1915 would have occurred probably from buds near the ends of the branches, thus making a top composed of long, slender, "leggy" limbs instead of having the compact framework that is seen developing in Figure 7. Perhaps this tree is not quite as tall now as it was in Figure 5 before it was pruned in November, 1914, but it is more stocky and in better shape for its future development than it would be if it had not been headed back.

Figures 8 and 9 illustrate still further the idea expressed in Figures 4 to 7 with reference to developing trees with stocky, open tops. These show an Utter apple tree that was planted in the spring of 1912. The photographs from which these illustrations were made were taken in November, 1914, before and after pruning. The tree then had completed three seasons' growth. From the beginning, it has been handled with a view to keeping the top open. As may be seen from Figure 8, in comparison with Figure 9, it was necessary to remove but little wood at this pruning, even though the current season's growth had been very strong, many of the limbs having increased 2 feet or more in length. The tree was started the first year with a framework of four or five branches. With these to serve as a foundation and with a small amount of corrective pruning each year the tree remains within easy control.

In contrast with the average apple tree to be found in this area, the one shown in Figure 9, as it here appears, may seem to many to be entirely too open. During the next season, however, the development of leaves and many small side branches, which may be expected eventually to form fruit spurs, causes the tree to present a very different appearance, as shown in Figure 10. As seen here it is in its fourth season's growth. It will not be headed back very much in the pruning which it receives in the future. Heavy heading back tends to stimulate additional wood growth. This tree has now been well shaped. The limbs that form the framework of the top, as well as the trunk, are stocky and strong. It is in good condition to begin to bear fruit. There is, therefore, no further need of pruning to encourage additional wood growth, but more or less thinning out of the top probably will be necessary each year. Slight heading in at times may be advantageous, but the foundation work, so far as pruning is concerned, has now been completed.

The keeping of the top well opened during the first few years is favorable for the development of spurs and short branches along the

limbs, thus tending to the production of a large bearing surface. It is on such growth that many fruit buds subsequently develop. This so distributes the fruit on the main limbs that there is the least possible danger of their breaking from its weight.

It should be stated, however, that there is much yet to be learned about the effect of heading back the annual growth year after year. If trees with strong stocky limbs are to be developed, rather heavy heading in for several years after planting seems as a rule to be necessary. On the other hand there is considerable evidence that if this practice is carried too far it very materially retards the time of bearing. Moreover, in this respect, it seems probable that trees of different varieties should be handled differently. Some varieties naturally make a strong stocky growth and do not branch excessively, while others develop long, slender branches. Obviously these two types of trees should be treated differently with respect to pruning.

FIG. 13.—A Wealthy apple tree planted in the spring of 1908, which received no further pruning until after its third season's growth. Because of these years of no pruning it has not been possible in more recent years to bring the top to a desirable form. Akron, Colo., November 11, 1914

It is, of course, desirable that a tree should come into fruiting as early as possible after it is planted, but the gain of a year or two in earliness of bearing is of small importance compared with the development of a type of tree which in later years will best meet the ends for which it is grown. It is the nice balance between earliness of bearing and other characteristics and the development of a tree which in the long run shall be best suited to fulfill the ends in view that constitutes the real problem in pruning during the early life of an orchard.

In rather strong contrast to the trees shown in Figures 4 to 10 are those in Figures 13 to 17. The latter illustrate apple trees planted in the spring of 1908. The photographs used in making

these illustrations were taken in November, 1914, after the trees had completed their seventh season's growth. Because these trees are considerably older than those shown in Figures 4 to 10, the illustrations in the two groups are obviously not entirely comparable. Yet they show certain contrasts that are of fundamental inportance in pruning fruit trees at the time of planting and during the first three or four years thereafter.

In contrast to Figures 4 to 10, Figures 13 to 17 show apple trees that were not trimmed with any particular ideal in view when they were planted, and they received no further pruning until after they had completed their third season's growth in 1910. Since then they have been pruned each year. To the casual observer the objectionable features of these trees may not be conspicuous, but they become very real to the one who wishes to prune them in a rational manner.

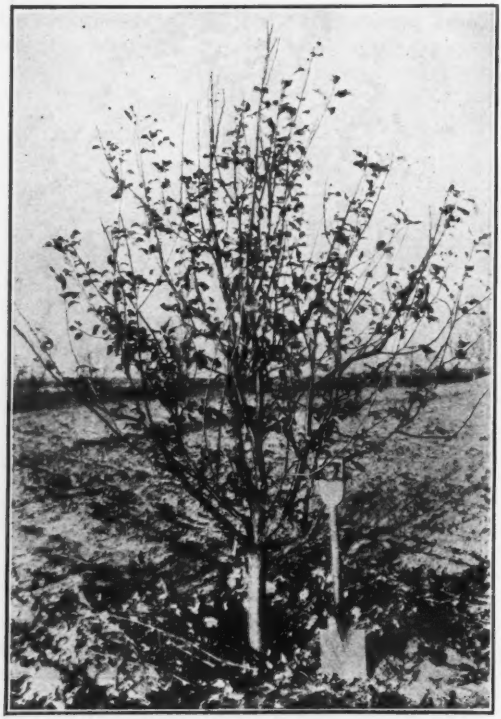

FIG. 14.—The Wealthy apple tree shown in Figure 13 after being pruned. Akron, Colo., November 11, 1914

Figures 13 and 14 show a Wealthy apple tree and Figures 15 and 16 a Patten tree in November, 1914, before and after pruning. Figure 17 is a Northwestern Greening apple tree not yet pruned in 1914. It will be seen by reference to the figures showing the trees before pruning that the tops are not extremely dense, as at the time the photographs were taken (November 11, 1914) a good deal of the foliage had dropped. When the pruning was begun in 1910, following three years of unrestricted growth, the tops of these trees were veritable heaps of brush. The pruning since 1910 has been directed primarily toward the gradual removal of superfluous wood. However, because of the fact that the trees were not well formed at the time they were planted and during the first year or two thereafter, the pruning in subsequent years has failed and must continue to fail to reduce the work to the simple, systematic operation that it is in the case of trees that are well pruned from the beginning. Most of the branches in

these three trees (figs. 13, 15, and 17) are relatively long and slender because they radiate so largely from a common axis or nearly from a common center. To keep the tops suitably pruned is difficult. If one of the larger limbs with its component branches is removed to open the top, the result is an unsymmetrical head; one side is made considerably lighter than the other.

The alternative in maintaining the tops sufficiently open for the free access of sunshine and air is to cut away a considerable number of the smaller branches. This tends toward the development of long slender unbranched limbs, with the bearing surface a little later in the life of the trees occurring only near the extremities.

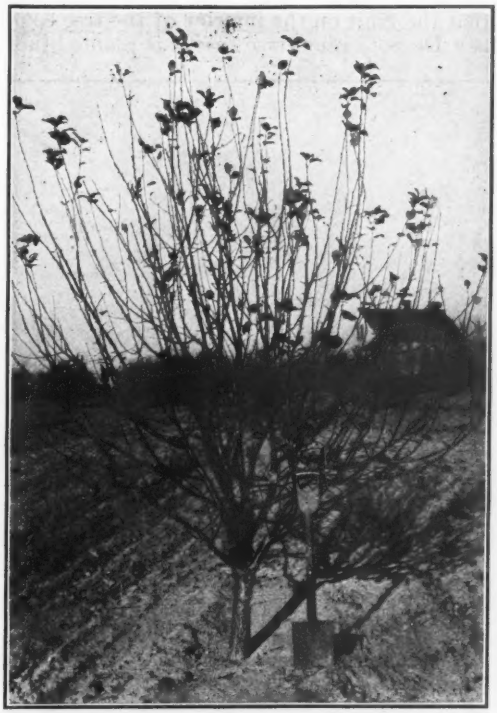

FIG. 15.—A Patten apple tree planted in the spring of 1908, which has received treatment similar to that of the Wealthy apple tree shown in Figure 13. Akron, Colo., November 11, 1914

The point in question is especially evident in Figure 17, where the tendency to make long, slender growth is very conspicuous, in spite of the effort made during the past three or four years to put the tree into the best shape that its condition has permitted.

A study of the illustrations here used emphasizes the fact, which all fruit growers recognize, that the natural habit of growth of different varieties must be considered in intelligent pruning. The upright habit of the Wealthy tree (figs. 13 and 14) and the roundish form of head shown by the Patten (figs. 15 and 16) and the Northwestern Greening trees (fig. 17) make the problem of pruning these two types quite different in each case, even though the principles involved are the same. The Utter tree in Figure 8 shows still another type of growth in that, even if left entirely unpruned, the top would not be likely to become as dense as that of the other varieties illustrated, because it does not branch so profusely. It is therefore less trouble to keep it well pruned, though the principles are the same as in pruning trees of the more profusely branching type.

The manner of pruning other fruit trees does not differ in principle from that followed with apple trees. Ordinarily the tops of plum and cherry trees are not kept quite as open as apples, principally because of the greater natural tendency to form fruit spurs along the branches; but if due attention is not given to the proper forming of the tops when planted and to wise pruning subsequently, the same troubles as those detailed for apples are sure to follow. This fact is made evident by Figure 18, showing a native plum tree planted in 1908, as were the older apple trees referred to, which formed a head so dense that it was only with considerable difficulty that the fruit on the interior of the tree could be picked. Figure 19 is a De Soto plum tree that was planted in 1909. This variety does not make naturally as dense a growth as does the one in Figure 18; besides, it was planted one year later, so that it began to receive systematic pruning that much earlier in its life. These plum trees have been headed back to some extent during the past three or four years, but they will not be likely to require very much more heading back.

FIG. 16.—The Patten apple tree shown in Figure 15 after being pruned. Akron, Colo., November 11, 1914

The Early Richmond cherry tree in Figure 20 was also planted in 1909. It has responded fairly well to the corrective pruning that it has received during the past three or four years.

Another problem in pruning is suggested by the tree shown in Figure 21. In some parts of the Great Plains area rather strong winds blow much of the time. The influence of such winds can be more or less checked as a rule by growing a well-arranged system of shelter belts that extend across the path of the prevailing winds. A little can be accomplished also by pruning. The branches should be kept well headed in. This heading in may need to be done during the growing season if a long, slender growth is being developed and it is being continuously forced far from its normal position. The top, if kept well opened, will offer less resistance to the wind than where it is allowed to become dense. Besides, if the tops are not too dense the branches will probably be less impeded in resuming their normal positions when the wind is

not blowing. However, a complete counteracting of the influence of strong prevailing winds is hardly to be expected except as the force of the winds is broken by shelter belts of some kind.

Great emphasis has been placed on pruning with a view to keeping the tops open. There are other reasons why systematic annual pruning should be done. Without regard to the order of relative importance, the more evident reasons may be enumerated as follows:

(1) Every branch is reaching out for sunlight. If the top is sufficiently open so that every leaf receives its full complement of sunshine there is less competition among the different branches than where the top is very dense.

(2) With the decreased struggle for existence among the branches, the crowding of the weaker ones and the resulting dead wood in the top of the tree are largely eliminated.

(3) The development of fruit-bearing spurs well within the center of the tree is encouraged because they receive sunlight, and sunlight in full measure is essential to healthy, vigorous growth.

(4) When a tree reaches bearing age it can be sprayed thoroughly, and it is evident that spraying will be necessary in this area if good fruit is to be grown. Besides, the fruit can be picked with reasonable ease and comfort. But not so if the picker must crawl through a brush pile to reach it.

(5) The above reasons are common to all fruit-growing regions. Another is of special significance on the Great Plains because of the limited rainfall. The conservation of the moisture in the soil is of the greatest importance. Great quantities of moisture are taken up by a tree and given off through the foliage. In general, the greater the amount of foliage the more rapidly is moisture given off. By proper pruning and thereby the holding of the top to a form or condition as to the number of branches and the amount of foliage which are most consistent with the objects for which the tree is desired, the less will be the loss of moisture from the soil through the foliage. Hence, it follows that wise pruning helps to conserve soil moisture.

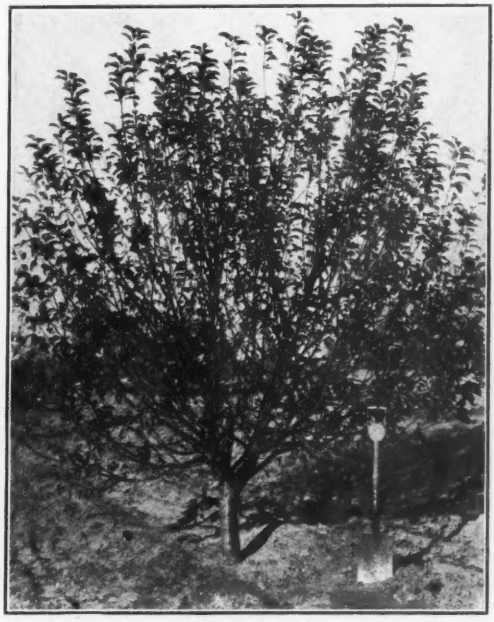

FIG. 17.—A Northwestern Greening apple tree planted in the spring of 1908, which has received treatment similar to that of the Wealthy apple tree shown in Figure 13. This is the largest apple tree in the garden. Akron, Colo., November 11, 1914

IRRIGATION

Although fruit growing on the average ranch in the Great Plains area must be largely under dry-farming methods, a relatively small quantity of water for irrigation may sometimes save fruit trees,

and especially strawberries and other small-fruit plants, during a particularly dry period.

Wells of large capacity and windmills are to be found on many ranches and often furnish an adequate supply of water for use in tiding fruits over a crisis of drought. On other ranches a supply of water for emergency use is sometimes stored in earth reservoirs, as suggested in Figure 22.

FIG. 18.—A plum tree of unknown identity planted in the spring of 1908, which is the largest tree of any kind in the garden, though during 1914 the apple tree shown in Figure 17 nearly overtook it. It has received treatment similar to the Wealthy apple tree shown in Figure 13, but it is in better shape for a plum than the Wealthy is for an apple. Akron, Colo., November 11, 1914

Such a reservoir is made by excavating the earth and mounding it up somewhat about the edge or rim. The inside is then puddled with clay or in some other way made sufficiently impervious to water to prevent seepage. Obviously, it should be located if possible on a slightly elevated site. It may be filled from the ranch well when the water is not required for other purposes, and the water may be siphoned out when wanted for irrigation.

ORCHARD PESTS

The orchard pests in the Great Plains area are not known to be essentially different from those in other regions except as they are influenced by regional, primarily climatic, conditions.

On account of the comparative dryness of the atmosphere, fungous diseases are not as prevalent as in the humid regions, where conditions are more favorable for their development.

Insects, such as the codling moth and currant worm, may be expected to occur. It may be assumed that the methods of control that are effective in other regions will be equally effective in this area.

Rabbits are likely to injure young trees during the winter by gnawing the bark, and in some sections pocket gophers and prairie dogs may be troublesome. Information regarding the control of

these pests can be obtained by addressing the Department of Agriculture.

Sun scald sometimes occurs during the winter on the south or southwest side of the trunks, especially in the case of high-headed trees. Injuries of this kind can be prevented by shading the trunks in some way during the winter. Binding laths, narrow strips of board, or cornstalks about the trunks, or even wrapping them with newspapers, will furnish all the protection needed. The material used should be removed in the spring.

HAIL INJURY

On September 22, 1910, the trees in the Akron fruit garden were seriously injured by a hailstorm. The results may be of interest in connection with the handling of trees in other parts of this area which may be injured by hail. The oldest trees in the garden were completing their third season's growth when the storm occurred. The bark on the north side of the trunks and larger limbs of many of the trees was badly bruised, and in some instances practically torn from the trees. Nearly all varieties of apples and cherries sustained substantially the same degree of injury. There were several varieties of apples, however, that appeared as if by chance to escape in a slight degree, but it is hardly to be assumed that this was due to any greater resistance of these particular sorts to the hail. Most of the plum trees passed through this storm with relatively less injury than that received by the apple, pear, and cherry trees. The tops of the peach trees were practically killed.

FIG. 19.—A De Soto plum tree planted in the spring of 1909, which has received treatment similar to the other trees planted prior to 1911, but as its tendency to branch is less pronounced the top never became as dense as some of the other sorts. Akron, Colo., November 12, 1914

During the two years following this injury the tops of a good many of the apple trees died, and to some extent those of other kinds also. The seriousness of the wounds on the trunks became very evi-

dent. In many instances where the tops were injured beyond recovery, good, strong sprouts developed from some point along the trunks. The one best suited for renewing the top was selected and the original top cut away.

The results which followed such serious hail injury have made it clear that the wiser course as a rule is to dig up and discard trees that show severe damage, especially where they have been planted only two or three years. If they have reached bearing age, or nearly so, it may be worth while to do everything possible to aid the trees in outgrowing the injuries.

During the eight years since this garden was established the hailstorm that took place on September 22, 1910, is the only one that has caused injury of any consequence in this garden.

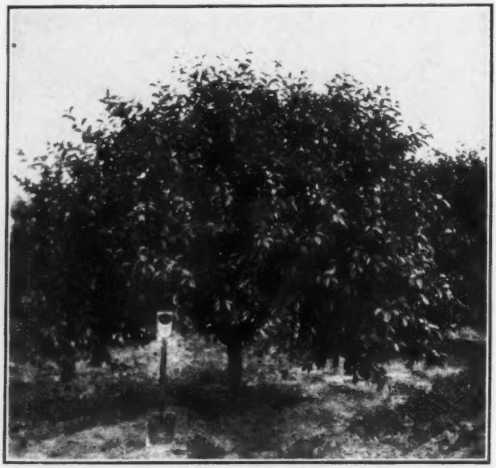

FIG. 20.—An Early Richmond cherry tree planted in the spring of 1909, an example of a tree that did not receive proper pruning and shaping of the top the first two years, but which has responded fairly well to corrective pruning during the past three or four years. Akron, Colo., July 20, 1915

FRUIT VARIETIES SUGGESTED FOR PLANTING

Although the cultural methods used in fruit growing in this area have much to do with the measure of success that is attained, they are not more important than the selection of varieties that are adapted to the conditions. In fact, the choosing of the best varieties, especially of the tree fruits, for planting in the different sections of the area is really more of a problem than to determine what methods of culture to adopt. This is true in a measure with regard to every region in which fruits are grown. But where the conditions, as in this area, are especially trying and present at best but a rather narrow margin between possible success and prohibitive limits, the problem of varieties becomes especially acute.

As mentioned in the discussion of the climatic conditions, the limited moisture, relatively low temperatures, and, in some parts of the area, a good deal of wind which increases evaporation make a combination of climatic influences that is very trying to fruit trees.

Not all varieties will do equally well throughout the Great Plains. In the southern part of the area the winter temperatures are much milder than they are in the north, but the wind is a more serious factor in the south than in the north. The very low winter temperatures reached in the north make it possible to grow only the fruits that have a high degree of resistance to cold.

Although very much yet remains to be determined with reference to the adaptability of varieties to the Great Plains area, it is believed that the mention of a number of different fruits which have been planted more or less may be suggestive and of some help to those who are without experience in choosing varieties to plant in this part of the country.

APPLES

Southern section.—A few of the varieties of apples that may well be considered for the southern part of this area are the Yellow Transparent, Red June, San Jacinto, Maiden Blush, Gravenstein, Wealthy, Grimes Golden, Jonathan, Kinnard, Northwestern Greening, Texas Red, Winesap, Missouri Pippin, Arkansas Black, Ralls, and Limbertwig; for crab apples, the Florence, Hyslop, and Dartt. These varieties, named approximately in the order in which they mature, represent a long sequence of ripening, from the early to the long-keeping sorts.

FIG. 21.—A Northwestern Greening apple tree planted in the spring of 1911 at the Amarillo Cereal Field Station, Amarillo, Tex., as it appeared on July 23, 1915. The prevailing winds have blown so incessantly as permanently to force the branches to grow largely in one direction, thus making an unsymmetrical top

Central section.—Most of the varieties that succeed best in the southern part of the area could doubtless be planted in the central section. However, the behavior of the fruits in the garden at the Akron Field Station may be used to further the information concerning varieties in this part of the area, at least so far as the growth of the trees is concerned. Reference to the various illustrations in this bulletin showing apple trees in this garden will be of assistance in this connection.

Among the older trees in the garden, the following seem especially promising for this section: Yellow Transparent, Oldenburg, Wealthy, Northwestern Greening, Patten, and the Hyslop crab.

Other varieties that have been planted include the Benoni, Delicious, Eastman, Jonathan, Lowland Raspberry, Longfield, McIntosh, Malinda, Okabena, Peerless, Peter, Plumb Cider, Stayman Winesap, Tolman Sweet, Utter, and Windsor, and the Dartt, Lyman,

Minnesota, Transcendent, and Whitney crabs, most of which have made good growth.

These varieties appear to be sufficiently hardy to withstand the normal conditions in this region, but thus far they have been disappointing in fruit production. Though old enough to bear considerable fruit as compared with other sections, they have produced very little here.

A number of dwarf apple trees were planted during the first year or two following the establishment of the garden. These include the Yellow Transparent, Oldenburg, Gravenstein, Wealthy, Bismarck, McIntosh, Esopus Spitzenburg, and Northern Spy. Thus far these trees have done well, and their behavior is such as to make them seem rather promising. Dwarf apples can not be recommended for

FIG. 22.—An earth "tank," or reservoir, for irrigating small gardens and fruit plantations. (From Bureau of Plant Industry Circular No. 51, entitled "Fruit Growing for Home Use in the Central and Southern Great Plains")

planting, however, until after they have more definitely demonstrated their value.

Northern section.—Naturally the varieties that can be planted in this part of the area must be restricted to the hardier sorts on account of the extremely low winter temperatures. These include the Oldenburg, Wealthy, Hibernal, McMahon, Northwestern, Greening, Patten, Malinda, the Hyslop crab, and possibly some others named in the Akron Field Station list for planting where the conditions are not too extreme. There are some localities in this section, however, where even the hardiest sorts would be of doubtful value.

PEARS

There are hardly enough pears now growing in this area to show the range of their possibilities, unless their comparative absence is

to be interpreted as signifying that they are not well adapted to these conditions. The Kieffer, Duchesse d'Angouleme (*Duchess*), Bartlett, and possibly one or two other sorts are occasionally grown in the southern part of the area. A variety supposed to be the Warner has grown well at the Akron Field Station, but has produced only lightly. The Flemish Beauty is one of the hardiest sorts and sometimes succeeds farther north than most other varieties.

PEACHES

Peach growing in this area is largely confined to the southern section, where a considerable number of varieties are grown to a limited extent. These include the Alexander, Sneed, Triumph, Arp, Carman, Mamie Ross, Chinese Cling, Elberta, Heath Cling, General Lee, Lemon Cling, and others.

At the Akron Field Station peach trees, including a number of the hardier sorts, were killed to the ground, or nearly so, every winter.

PLUMS

Plums, particularly the native sorts, are among the most dependable of all the tree fruits for planting on the Great Plains. They have been planted quite widely throughout most of this area, and there is a fairly large number of varieties from which one may choose. Of these the following are named, especially for the southern sections: America, De Soto, Golden (*Gold* of Stark Bros.), Kroh (*Poole's Pride*), Pottawattamie, Six Weeks, Surprise, Wildgoose, Wolf, and Wyant.

Among the more promising varieties at the Akron Field Station are the following: Brittlewood, Emerald (*Burwood*), Cheney, De Soto, Surprise, Terry, Wolf, and Wyant. The identity of the plum shown in Figure 18 is unfortunately unknown, but it is one of the most promising sorts in the Akron garden. It resembles the Brittlewood somewhat and may prove to be that variety. Most of these varieties have been planted widely throughout the Great Plains area. Several varieties of European plums, including the Lombard, Arctic, Shropshire (Damson), and others, have also been planted at this station. None of them can be considered promising. The trees make only small growth as a rule, and they do not withstand the winter conditions in a satisfactory manner.

In parts of the northern section the following varieties are more or less grown: Cheney, De Soto, Forest Garden, Surprise, Waneta, Wolf, and Wyant. Some comparatively new sorts that appear to merit testing are: Elliot, Red Wing, Tonka, and Underwood.

The native plum trees in the fruit garden at the Akron Field Station have not been very long lived as a rule. In fact, in nature where they occur in thickets, the perpetuation of the latter is usually dependent largely on the growth of sprouts or seedling trees. The trees in the center, and others as they attain age, are apt to weaken and die. The grower therefore should not be discouraged if he finds it necessary to replant plum trees every few years. It would probably be wise to make new plantings occasionally in anticipation of the loss of older trees through natural causes.

CHERRIES.

Of the tree fruits, sour cherries are perhaps of equal value with native plums for this area. The number of varieties commonly grown is small, the Early Richmond, Montmorency, and English Morello comprising nearly all the trees that have been planted; in fact, there are probably to be found many times more trees of a single variety—the Montmorency—than all the others combined. These varieties are successful generally in the central and southern sections, as well as in some parts of the northern section, but in the latter there are large regions where the conditions practically preclude the growing of cherries. The Zumbra, a recently introduced variety, is promising for some parts of the northern Great Plains. It is a supposed compound hybrid of a pin cherry, a sweet variety, and the sand cherry.

An Early Richmond cherry tree planted at the Akron Field Station in 1909 is shown in Figure 20. Several trees of the Black

FIG. 23.—Sand cherries planted in the spring of 1911, fruiting heavily in 1913. Akron, Colo., July 19, 1913

Tartarian and other sweet cherries have also been planted at this station, but they have either died or are in an unsatisfactory condition. It is not believed that sweet cherries are likely to withstand the conditions anywhere in this area.

Sand cherries also do well in many parts of the Great Plains area. The ones shown in Figure 23 were planted in 1911 and fruited in 1913. The fruit is of value primarily for making jelly or preserves rather than for use in the fresh state. But as the sand cherry is native to the Great Plains, doubtless selections could be made which would bear fruit of fairly good edible quality.

SAND CHERRY—PLUM HYBRIDS

Of this type of fruit the Compass cherry, a hybrid between the sand cherry and the Miner plum, has been widely planted in this area. It is proving to be of distinct value. Trees planted at the Akron Field Station in 1910 began bearing in 1912 and produced

good crops in 1913 and 1914. Though not of high quality, the fruit is very acceptable. The tree comes into bearing early and seems to be perfectly hardy here. Figure 24 shows a Compass tree, planted in 1910, as it appeared in November, 1914. The tree makes a very open growth; practically no thinning out of branches has been done in the tree shown here.

A number of other varieties of the same general type have been developed and in recent years have been planted more or less. They are desirable for the Great Plains area generally, being very hardy and seemingly well adapted to the conditions under which many other fruits fail. The Opata, Sapa, Sansoto, and Hanska are the better known varieties of this group of hybrids.

FIG. 24.—A Compass cherry planted in 1910. The open, spreading habit of growth is to be noted. Akron, Colo., November 11, 1914

CURRANTS

Currants appear to be one of the most satisfactory small fruits for the Great Plains. Most varieties do about equally well and are generally hardy. The London Market is perhaps grown in larger quantities than any other sort, but the Cherry, Victoria, Red Dutch, and North Star, for red sorts, and the White Grape, for a white variety, have done well at the Akron Field Station and include the sorts most commonly found elsewhere in the Great Plains area.

The plants as a rule are a little slow the first year in getting started, but when well established they make a good growth if properly pruned. Figure 25 shows some currant bushes planted in 1909 or 1910 which are quite typical in growth of all the varieties at the Akron Field Station.

GOOSEBERRIES

In general, what has been stated regarding currants is true also of gooseberries. They are quite dependable wherever currants are succeeding.

As in the case of the latter, the plants are a little slow in getting established and do not often make a very strong growth the first season. After they are once well established, they appear to be hardy. To keep them vigorous, however, the sprouts that habitually grow from the ground in rather large numbers should be kept well thinned out.

Probably the Downing, Houghton, and Poorman can be planted generally in this area with as much assurance of satisfaction as any other varieties.

RASPBERRIES, BLACKBERRIES, AND DEWBERRIES

Raspberries, blackberries, and dewberries have not proved very successful in this area, and they have not been planted as a rule in the ranch fruit gardens. Generally speaking, they do not withstand dry weather well. Even in the humid sections heavy losses sometimes occur as a result of drought.

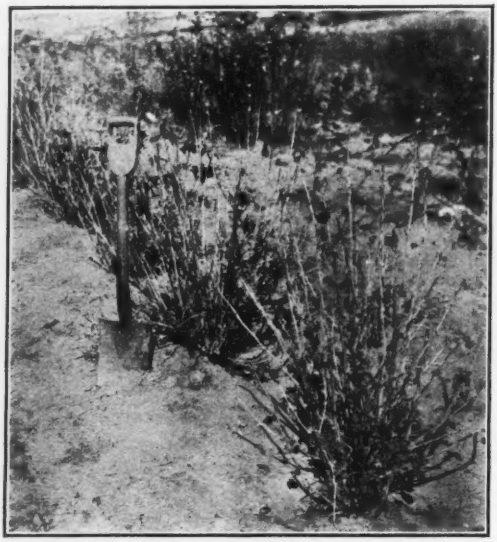

FIG. 25.—Currant bushes planted about 1910, showing typical growth. Akron, Colo., November 11, 1914

In many instances in this area the plants are slow in starting growth after being set out, though when once established the roots are quite persistent. The canes, however, are very apt to kill to the ground during the winter. To some extent winter injury can be prevented by bending the canes to the ground and covering them with soil, but how widely this method of winter protection can be used successfully is not definitely known.

Of the varieties observed in this area there seems to be but little, if any, real preference, as there has been no important difference in their behavior. Of the raspberries, the Cuthbert, Loudon, King, and Sunbeam, for red sorts, and the Cumberland, Kansas, and Winfield, for black varieties, have been planted at the Akron Field Station. They have all borne a little fruit; possibly the Sunbeam has done fully as well as any variety. The canes of all varieties have winter-killed so badly that there is little choice for planting. No winter protection, however, has been given them. The Latham, one of the newer red varieties, is suggested for trial.

Blackberries at the Akron Field Station have behaved in essentially the same manner as the raspberries. They are rather slow to start into growth after planting. The canes have been killed back

to the ground, or nearly so, every winter, and practically no fruit has been produced. The Himalaya, a variety the canes of which are perennial and normally do not die after producing a crop of fruit, as do the ordinary varieties, has made a fairly strong growth each year. However, it is not hardy enough to withstand the winters, though it does not usually kill back as far as do the other sorts. It has produced a very small quantity of fruit, which ripens over a long period, and only a few fruits are ever ripe at the same time, even on 10 or 12 large plants. The berries are small and imperfect, merest nubbins, and the proportion of seed to pulp is so large as to make the fruit almost inedible. Besides the Himalaya, the Snyder, Mersereau, and Rathbun varieties have been planted, none of which seem to be promising for this area.

Only one variety of dewberry, the Lucretia, has been planted. This bore a little fruit in 1912, but in general its behavior has been the same as that of the raspberries and blackberries.

It is probable that much of the winter injury to these fruits is due to the limited moisture supply rather than to the direct effect of low temperatures, especially in the southern and central sections. In the northern part of this area extreme cold is doubtless a limiting factor in itself, except where the plants are adequately protected. To the extent that the difficulty is a matter of moisture, proper irrigation before the ground freezes in the late fall might be of considerable importance.

STRAWBERRIES

Success with strawberries in this area seems to be more largely a matter of the plants becoming well established and having an adequate moisture supply during certain periods than in the planting of any particular variety; in fact, the establishment of the plants is usually dependent upon a suitable amount of moisture in the soil. The roots are so near the top of the ground, at least until after growth has been well renewed, that they are very susceptible to the surface conditions of the soil. The roots of strawberries may dry out completely before a new growth starts, where other kinds of plants with their roots deeper in the soil would not be seriously affected. Hence, if newly set plants can be watered as needed until they are well reestablished after transplanting, the chief danger of failure in the beginning is eliminated. Unless this can be done, the plants will die in many cases before a new growth starts.

It is also important that water be available for use during the development of the fruit. At this period the strawberry requires a relatively large quantity of water. If it is lacking, the fruit will be small and much of it may fail to develop.

By mulching with straw during the winter to prevent repeated thawing and freezing as well as to protect the plants from extreme temperatures, strawberries can probably be grown almost anywhere in the Great Plains, provided water can be applied during the critical periods mentioned.

While irrigation might be quite advantageous at times in the growing of other fruits, it may often be practicable to water a small strawberry bed that can be located near the dwelling house, when it would be out of the question to water a fruit garden more or less distant from the buildings.

As to varieties, the Dakota and Dry Weather in the northern section, the Dunlap in the central, and the Klondike in the southern section, are suggested.

JUNE BERRIES

Not many June berries have been planted in this area. As a rule they do not make a very vigorous growth, but appear to be hardy when well established and may be expected to bear considerable fruit. The fruit, while not of high quality, will add an agreeable variety for home use.

BUFFALO BERRIES

Of the wild fruits that are native to this area the buffalo berry is worth consideration, especially for the northern sections, where the range of fruits that can be grown is more limited than in other parts of the area. The fruit is small and very sharply acid. Its most important use is probably for making jelly, though it is eaten in the fresh state to a limited extent.

The fruit-producing blossoms are borne on separate plants from those that bear the pollen-producing blossoms. As only the former bear fruit, bushes for planting should be largely of that type, though a small proportion of the others must also be planted to supply pollen for the fertilization of the fruit-producing blossoms.

GRAPES

There is very little definite knowledge concerning the possibilities of grape growing in this area. Low temperatures in the north are largely prohibitive, but in some parts of the other sections it is probable that a measureable degree of success could be obtained, especially in localities where wild grapevines are found. The following varieties, among others, have been tried to a limited extent in this area: Beacon, Beta, Captain, Carman, Concord, Fern Munson, Headlight, Herbemont, Janesville, Lenoir, Marguerite, R. W. Munson. However, no special recommendations or suggestions as to their adaptability to any part of the Great Plains can be made at this time.

MIXED PLANTING ADVISABLE

Attention should be here called to the fact that many varieties of apples, plums, pears, cherries, and other fruits are more or less sterile with their own pollen. Such varieties, therefore, may be unfruitful, even though they blossom abundantly, unless planted in close proximity to other varieties of the same kind which blossom simultaneously with them. While not all varieties are self-sterile, and sometimes those which are so under certain conditions are not self-sterile under others, the matter is of too great importance to be disregarded when planting orchards or fruit gardens. It is therefore always wise to select at least two varieties of each kind of fruit for planting, unless one has good evidence that under his conditions a variety which he desires is self-fertile.

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84F

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IN THE GREAT PLAINS AREA

XUM

As in the case of the latter, the plants are a little slow in getting established and do not often make a very strong growth the first season. After they are once well established, they appear to be hardy. To keep them vigorous, however, the sprouts that habitually grow from the ground in rather large numbers should be kept well thinned out.

Probably the Downing, Houghton, and Poorman can be planted generally in this area with as much assurance of satisfaction as any other varieties.

RASPBERRIES, BLACKBERRIES, AND DEWBERRIES

Raspberries, blackberries, and dewberries have not proved very successful in this area, and they have not been planted as a rule in the ranch fruit gardens. Generally speaking, they do not withstand dry weather well. Even in the humid sections heavy losses sometimes occur as a result of drought.

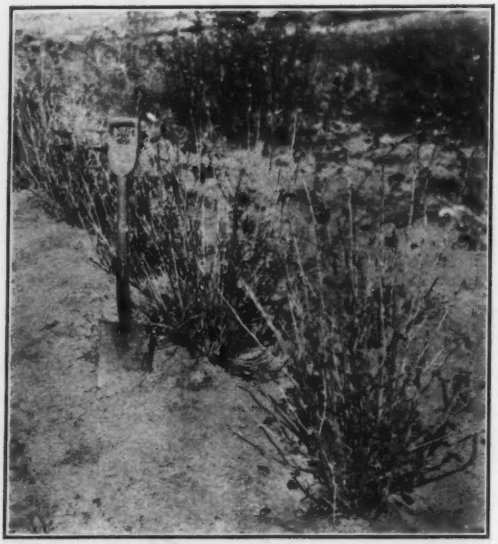

FIG. 25.—Currant bushes planted about 1910, showing typical growth. Akron, Colo., November 11, 1914

In many instances in this area the plants are slow in starting growth after being set out, though when once established the roots are quite persistent. The canes, however, are very apt to kill to the ground during the winter. To some extent winter injury can be prevented by bending the canes to the ground and covering them with soil, but how widely this method of winter protection can be used successfully is not definitely known.

Of the varieties observed in this area there seems to be but little, if any, real preference, as there has been no important difference in their behavior. Of the raspberries, the Cuthbert, Loudon, King, and Sunbeam, for red sorts, and the Cumberland, Kansas, and Winfield, for black varieties, have been planted at the Akron Field Station. They have all borne a little fruit; possibly the Sunbeam has done fully as well as any variety. The canes of all varieties have winter-killed so badly that there is little choice for planting. No winter protection, however, has been given them. The Latham, one of the newer red varieties, is suggested for trial.

Blackberries at the Akron Field Station have behaved in essentially the same manner as the raspberries. They are rather slow to start into growth after planting. The canes have been killed back

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8 F

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IN THE GREAT PLAINS AREA

FRUIT GROWING in the Great Plains area is a home-making rather than a money-making unit in farm-ranch organization. However, anything that adds to the comfort, satisfaction, and well-being of the home often makes returns far in excess of the money value that can be placed upon it. Not all values of material things are money values.

Though the hazards of spring frost, drought, and other climatic factors in this area are too great to justify the planting of any kind of fruit with a view to its becoming a main money crop, there are few seasons when more or less of a yield of some kind—plum, cherry, currant, gooseberry, or other hardy fruit—can not be produced in most sections. An effort to have home-grown fruit every year is very much worth while. Whenever a fruit garden in this area produces a surplus, there need be no fear of an overstocked market to interfere with its ready sale at good prices. Not infrequently ranchers travel many miles to get fruit from some orchard that has developed a commercial surplus.

Although the general methods of fruit culture do not differ greatly in the Great Plains area from those in other sections, there are details of practice of peculiar importance and precautions which if fully observed may help to counteract some of the naturally adverse climatic conditions. The selection of varieties that are the best adapted to these conditions is also fundamental to success.

Washington, D. C.

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GROWING FRUIT FOR HOME USE IN THE GREAT PLAINS AREA

By H. P. GOULD, *Senior Pomologist, Division of Horticultural Crops and Diseases,* and OLIVER J. GRACE, formerly *Superintendent, United States Dry Land Field Station, Akron, Colo.*

CONTENTS

	Page		Page
Introduction	1	Proper distances for planting	11
Sites for fruit plantations	3	Tillage	13
Climatic features of the Great Plains	4	Pruning	16
Preparation of the land for planting	6	Irrigation	23
Nursery stock	6	Orchard pests	24
Handling the stock when received from the nursery	8	Hail injury	25
Planting the trees and other nursery stock	9	Fruit varieties suggested for planting	26
		Mixed planting advisable	34

INTRODUCTION

DURING recent years a transformation of large import has been taking place in the Great Plains area. From a vast territory devoted largely to the grazing of cattle and with a very small population it has become an area in which great quantities of grain and other crops are produced annually, with a corresponding increase in the number of homes. Though some sections are still very sparsely settled, the aspect of the entire area has been materially changed by the influx of people who have come from many different parts of the country.

The Great Plains area is not "a natural fruit country," as those regions in which native fruits abound or where the conditions are especially favorable for fruit production are often called. On the other hand, very few native fruits occur in this area, and comparatively little attention has been given to the planting of the cultivated fruits. However, many of the recent comers are from sections where they have been accustomed to grow what fruit was needed for home use. It naturally follows that in many instances upon establishing new homes in this area they have planted a few fruit trees. As a result there are numerous ranches widely distributed throughout the Great Plains where some attempts are being made to grow a home supply of fruit.

NOTE.—This bulletin is intended especially for those in the Great Plains area who are interested in growing fruit for home use, but some parts of it, especially the discussion about pruning and shaping trees, are of general interest to people living in other sections of the country.

The information is based largely upon the results obtained in a dry-land fruit garden which was established in 1908 at the Dry-Land Agriculture Field Station of the Bureau of Plant Industry, Akron, Colo. Most of the illustrations are from photographs taken in this garden.

This bulletin supersedes Bureau of Plant Industry Circular No. 51, entitled "Fruit Growing for Home Use in the Central and Southern Great Plains."

In a few instances orchards of some commercial importance have been developed. Most of these are the outgrowth of one or more of several conditions: (1) The location has proved to be exceptionally well suited to the growing of fruit; (2) the owner has had considerable experience in fruit growing before coming to this section; or (3) the owner, as he has gained experience here with a small orchard, has found himself better qualified for the details of fruit raising than the ranchers generally, and has gradually increased his fruit interests to good advantage.

FIG. 1.—Sketch map of the Great Plains area, which includes parts of 10 States and consists of about 400,000 square miles of territory. Its western boundary is indicated by the 5,000-foot contour. Each dot within a circle (⊙) indicates the location of a field station of the Division of Dry Land Agriculture of the Bureau of Plant Industry

The surplus fruit from the home orchards, as well as that produced in those of larger size, always finds a ready sale, buyers sometimes driving many miles to obtain it.

Within the boundaries of the Great Plains area there are a few restricted districts that are under irrigation. In some of these, orchard interests of considerable commercial importance have been developed. These interests are not discussed, however, in this bulletin.

The tree fruits that occur most commonly in the dry-land ranch orchards are apples, cherries, and native plums. In some of the milder parts of the area, especially in the southern section, pears and peaches are more or less common, while still less frequently apricots are found. Currants and gooseberries are probably the most important as well as the most common of the small fruits. Juneberries, buffaloberries, and strawberries are sometimes to be found.

The successes and failures in this area, as in other sections, are very largely dependent upon the care and attention given by the

owner. In certain regions, however, it is difficult to succeed, whereas in others a complete fruit failure is comparatively rare. The one controlling factor in the Great Plains area, outside of those sections where water for irrigation is available, is the lack of moisture, yet after the trees have become well established it is not often that this causes more than temporary loss, such as a crop of fruit for a single season.

In some sections winds and hailstorms occasionally cause damage, but these losses are not more frequent with fruits than with the field crops. However, the trees sometimes suffer permanent damage from hailstones, even being killed in some cases.

The majority of the settlers on the Great Plains must depend upon their own plantations for a supply of fruit for home use. Most of those who do not have home-grown fruit are obliged to do without it. The chief interest, therefore, in the cultivation of fruit in this area centers about the home and the production of enough to meet the needs or desires of each family. In other words, fruit growing here is a home-making rather than a money-making enterprise.

The geographical position and extent of the Great Plains area are shown in Figure 1. Its western boundary, as indicated, is the 5,000-foot contour; its eastern boundary is arbitrarily placed at the ninety-eighth meridian.

SITES FOR FRUIT PLANTATIONS

Probably the greatest obstacle, either directly or indirectly, to the successful growing of fruit in the Great Plains area is lack of moisture in the soil. It follows, therefore, that the site for an orchard or small fruit garden should be selected with a view to securing the maximum supply of soil moisture. In many instances, particularly on the smaller ranches, the conditions are so nearly uniform that there is no choice in this respect. The convenience of the site with regard to the buildings will usually be the ruling factor in such cases.

But on many ranches there are sites that are more favorable for fruits than others on account of the soil-moisture factor; for instance, where a small stream or arroyo passes through the ranch it may furnish an additional supply of water. In some cases the topography is such that a reservoir can be made by building a small dam across the stream and diverting the water to the orchard. Not infrequently some of the larger streams that pass through this area have an underflow that extends some distance on either side. Where this condition prevails and the underflow is reached by their roots, the trees often make a remarkable growth.

Again, there are many instances where the lay of the land is such as to result in a large amount of run-off during heavy rains. If this run-off, which would otherwise be lost, can be collected in small contour ditches and distributed where fruits are planted, a considerable increase in the supply of moisture is secured. A coulee that opens away from the prevailing wind and traps quantities of snow is often an excellent place for an orchard. A shelter belt is almost essential in some places (fig. 21). Advantage should be taken of every factor which will increase or conserve the supply of moisture in the soil.

CLIMATIC FEATURES OF THE GREAT PLAINS

The climate of the Great Plains has been classified as semiarid. It may be better to say that it is variable. One season may have almost humid and another almost arid conditions. The mean annual precipitation is relatively low. Years of relatively high precipitation may be followed by years of relatively low precipitation. Other climatic factors usually correspond with the rainfall. In a year of relatively high rainfall there will be a lower rate of evaporation and higher humidity than in a year of low rainfall.

Another climatic factor of much importance in crop production on the Plains is the distribution of the rainfall. This is probably more important in crop production than the amount of annual rainfall. A relatively low rainfall, properly distributed, may produce a crop where a much higher rainfall, unfavorably distributed, may accompany a crop failure.

TABLE 1.—*Annual and seasonal precipitation and seasonal evaporation at 14 stations in the Great Plains area* [1]

Station	Altitude (feet) [2]	Precipitation (inches) [3]						Seasonal evaporation (inches) [3]		
		Annual			Seasonal					
		Minimum	Maximum	Average	Minimum	Maximum	Average	Minimum	Maximum	Average
Judith Basin	4,228	14.96	23.78	18.06	7.04	17.21	9.34	22.012	29.353	24.491
Huntley	3,000	11.92	11.92	11.92	5.92	6.02	5.79	23.754	24.214	23.984
Williston	1,875	10.28	18.99	14.84	4.75	14.49	9.66	20.422	26.877	24.216
Dickinson	2,543	11.93	21.22	16.69	6.85	16.28	9.79	20.673	25.745	23.919
Edgeley	1,468	11.94	21.95	16.71	7.85	14.98	10.11	18.663	24.893	21.866
Hettinger	2,253	12.72	15.68	14.20	8.92	12.47	10.36	21.539	28.239	24.639
Belle Fourche	2,950	6.64	17.73	13.11	4.08	9.78	6.90	26.472	33.750	28.794
Scottsbluff	3,950	13.77	18.51	16.14	2.53	8.52	4.69	23.804	29.381	26.081
North Platte	3,000	11.18	23.01	18.05	6.85	12.36	9.45	28.445	38.168	32.359
Akron	4,600	14.51	22.46	18.28	6.42	13.86	9.02	26.064	35.654	31.420
Hays	2,050	15.59	27.80	21.30	8.18	17.97	11.17	30.625	44.373	35.790
Garden City	2,900	11.82	23.58	18.54	2.79	14.43	8.65	34.325	43.510	38.185
Dalhart	4,000	13.69	16.35	15.11	5.09	9.85	8.01	35.459	41.748	38.988
Amarillo	3,676	10.69	27.80	18.28	6.17	11.38	9.13	33.804	42.076	36.724

[1] The period of time covered by the investigations made at the several stations ranged from two to eight years, depending upon the time when the different stations were established, the same period being covered by the data regarding precipitation and evaporation shown here.

[2] The altitude given is based in most cases on that of the nearest town.

[3] The records of annual precipitation for 1914 are not included. The records of seasonal precipitation and evaporation for 1914 are included for all stations, being figured from May 1 to Sept. 1. Evaporation measurements are made from a free water surface, in a tank sunk into the soil to almost its full depth. The water surface is kept about level with the surface of the ground

Table 1 gives the maximum, minimum, and average annual precipitation and the seasonal maximum, minimum, and average precipitation and evaporation of the Great Plains area. By seasonal is meant the period between the average time of seeding and the average time of harvest. * * *

Figure 2 shows the earliest and latest dates of the last killing frost in the spring, the earliest and latest dates of the first killing frost in the fall, and the average length of the frost-free period at each station. Each hatched horizontal bar represents the period between the average dates of the last killing frost in the spring and the first killing frost in the fall. The number of days in the average frost-free period for the station is shown in the figures above the bar. The solid-line curve at the left shows the earliest date at which the frost-free period has begun. The broken-line curve at the left represents the latest date at which the last killing frost of the spring has occurred. The solid-line curve at the right represents the earliest date and the broken-line curve at the right the latest date at which the first killing frost of the fall has occurred.

This diagram [fig. 2] shows clearly the increase in the length of the frost-free period from the north to the south. The shortest average period is 100 days, at Hettinger, and the longest 194 days, at Amarillo.[1]

[1] See Chilcott, E. C., Cole, J. S., and Burr, W. W., "Crop production in the Great Plains area: Relation of cultural methods to yields," U. S. Dept. Agr. Bul. 268, pp. 3–4, fig. 2. 1915.

In the Great Plains area the regional restrictions to fruit growing, so far as the natural conditions are concerned, are primarily factors of temperature and moisture.

In some sections of this area, especially the northern part, fruits for planting must be selected with a view to their hardiness and their ability to endure extremely low temperatures in winter. But throughout the Great Plains area as a whole unseasonable frosts during the blossoming period or at other critical stages of growth more often cause damage than extreme cold during the dormant period. However, the combination of relatively low winter temperatures, limited moisture supply, and drying winds that sometimes prevail is extremely trying on most fruit trees and may cause serious damage where any one or even two of these factors operating at the same time would not adversely affect the trees.

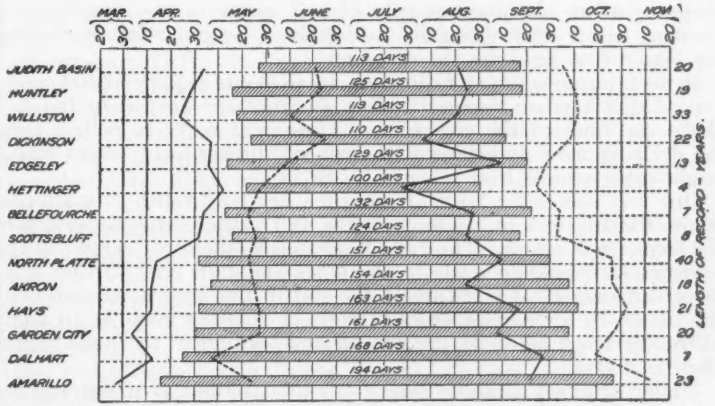

FIG 2.—Diagram showing the average frost-free periods and the earliest and the latest dates at which the last killing frost in the spring and the first killing frost in the fall has occurred at 14 stations in the Great Plains area

The general climatic features of this area are well indicated in the paragraphs above quoted. In that connection the statements are applied to the production of general agricultural crops, but they are none the less applicable to fruit growing.

Another climatic factor that occasionally does great damage is hail. Trees of considerable size are sometimes completely killed or so badly bruised or otherwise injured as to render them worthless. Hailstorms occur much more frequently in some parts of this area than in others. In sections where they are known to be severe, the planting of fruits is likely to prove disappointing.

Some sections of the Great Plains are further characterized by winds which blow almost continuously. While the wind may not be a prohibitive factor in the growing of fruit in any section it is a serious one where it blows much of the time. It not only results in the premature dropping of the fruit, but it becomes practically impossible to prevent the tops of the trees from growing very much to one side.

PREPARATION OF THE LAND FOR PLANTING

For fruits, land that has been in cultivation for one season or for a sufficient length of time for the sod to have become thoroughly rotted is very much to be preferred to newly broken land.

The planting of fruits in this area should be done as a rule in the spring, and in any special preparation that may be made the aim should be to handle the soil so that it will contain as much moisture as possible at the time the planting is done.

In seasons of fairly abundant precipitation, especially if there is considerable rainfall or fairly heavy snows during the winter, there may be enough moisture stored in the soil in the spring to insure the starting of the trees, even if a crop has been produced the previous season. But because of the wide seasonal variation in the amount of precipitation, frequently falling far below normal, and the importance of an abundant supply of soil moisture in the spring at planting time, it is generally advisable to summer-fallow during the season that precedes the planting.

In addition to summer fallowing, an adequate supply of soil moisture is still further insured if deep furrows are opened in the fall along the lines of the tree rows. These will serve to collect both the drifting snow and some of the run-off during heavy rains which might otherwise be lost.

One very successful fruit grower on a dry-land ranch even supplements the furrows by digging in the fall rather large holes where the trees are to stand. The run-off, as well as the snow caught in the furrows, will tend to settle in the holes and thus still further augment the amount of moisture in the soil in the immediate radius of the trees. In some cases, cross furrows or furrows made at an angle to the direction taken by the run-off and leading to the holes might also be useful.

Under ordinary climatic conditions this method of preparing the land should result in its being well supplied with moisture, and the trees should start into growth readily and make a good development of roots so far as the soil moisture is concerned.

NURSERY STOCK

In the central portion of the Great Plains area, as represented by the United States Dry-Land Field Station, Akron, Colo. (fig. 1), the most favorable period for planting is usually the last of April and early in May. It varies in other parts of the area from earlier in the southern section to somewhat later farther north. Normally, nursery stock is delivered in the spring rather than in the autumn. It is absolutely essential for success that it reach its destination in a perfectly dormant condition. Hence, it follows that while it may be satisfactory for those ordering stock for planting in the southern part of the area to secure it from northern sources, it is not well to obtain it from the south for planting in the northern sections, on account of the fact that the buds may start on stock from the south before the most favorable period for planting in the north has arrived.

On account of the arid or semiarid conditions of this region the period following the planting of the trees is very trying unless there

is a sufficient supply of moisture stored in the soil and available for their use. The moisture in the trees is being dried out constantly, and more rapidly than would be the case in a humid region. The roots of newly planted trees do not at first readily take up moisture from the soil, and if it is excessively dry the trees may die before they can start into growth. Because of these moisture factors it is of the greatest importance to procure only trees and other nursery stock which are most likely to start into growth readily and quickly when planted.

In many fruit-growing regions apple, pear, plum, and cherry trees are commonly planted when 2 years old; that is, after they have made two seasons' growth in the nursery from the bud or graft. However, in some commercial apple and cherry growing sections there is a strong sentiment in favor of 1-year-old trees for planting in preference to older ones. The younger trees have an advantage in that it is possible to form the tops at any desired height. The heads are already formed on 2-year-old trees when received. Not infrequently the trees have been headed too high to be desirable, and it is not always possible or practicable to plant such trees deep enough to overcome this objection. And, again, good, strong 1-year-old trees, as a rule, withstand transplanting fully as well as older trees; they are lighter to handle in shipping and in other ways are more desirable. This is true of other trees as well as of apples and cherries.

Inexperienced buyers of fruit trees not infrequently measure the value and grade of the trees delivered by their size; the larger the tree the better it is supposed to be. But experience has proved that thrifty, medium-sized trees are better for planting in the Great Plains area than larger ones, with a preference for good, strong 1-year-old trees. The larger 2-year-old trees as a rule do not withstand transplanting as well, nor are they as likely to live and make a good growth as the medium-sized ones of the same age.

On the other hand, a very radical distinction must be made between medium-sized or relatively small healthy trees and those which are small because they have been stunted by some adverse condition. Weak, stunted trees should be refused absolutely. They are likely to be expensive even as a gift.

Good root systems are also of special importance in satisfactorily starting trees planted under the conditions which normally prevail in this area. In sections where all the factors influencing growth are favorable, the difficulties incident to poor roots, if not too serious, may be overcome perhaps without permanently harmful results; but in the region under consideration well-developed and abundant root systems are especially important. If the roots of trees consist of only a very few large parts, new growth does not start as readily and as quickly as it does if the plants are well provided with a large number of small roots.

But here again caution is necessary. A large mass of very fine threadlike roots is due cause for suspicion. Such roots may indicate a disease known as hairy-root, a form of crown gall. Although there is a wide difference of opinion and experience concerning the seriousness of this trouble, it is by far the safer plan to discard trees so

affected; the roots in any event are abnormal and if planted there is always the possibility that the trouble will develop to such an extent as to affect seriously the vigor and durability of the tree. All trees and vines showing crown gall or abnormal growths of any kind should be rejected.

The height of the tree is as important as its root system. Trees that have been headed from 1½ to 2½ feet high as a rule start into growth more readily and develop better than trees headed 3 to 3½ feet high. In a large majority of cases the high-headed trees, even when they live, make only a very small growth the first season and rarely develop well-formed, satisfactory tops as they increase in age.

HANDLING THE STOCK WHEN RECEIVED FROM THE NURSERY

It has already been stated that planting in the spring rather than in the fall is to be advised in this area. To insure the timely arrival of the stock from the nursery it is wise to order it shipped with a view to its arriving at its destination a little in advance of the actual date of planting. Otherwise, an unexpected delay in shipping or during transit may result in inconvenience or in the undue starting into growth of the stock before it is received.

To hold trees and other plants in good condition until planted, they should be unpacked immediately upon arrival and heeled in without delay in a well-drained spot. The heeling in is accomplished by digging a trench 12 or 15 inches deep, sloping on one side. The roots are placed in the trench, the trunks of the trees lying at right angles to it on the sloping side. The position is illustrated in Figure 3. In case the trees are tied in bundles when received they should be separated; otherwise, the roots can not be properly protected. Moist, finely pulverized soil should then be worked thoroughly in among the roots, completely filling all the spaces, and the roots finally covered several inches deep.

If it is necessary for any reason to have the trees heeled in for a long time before they are planted, it may be advisable to cover the tops, entirely or nearly so, with soil, to prevent the sap from being dried out to an undue extent. With the first advent of warm weather, however, the branches should be uncovered.

The soil that is placed over the roots and such other parts of the trees as may be covered should be packed very firmly. This is not only for the purpose of excluding as much air as possible, but to lessen the danger of mice finding a harbor among the trees, where they might cause injury by gnawing the bark.

Trees that are heeled in should be examined frequently, with especial reference to moisture conditions. While the soil about the roots should not be kept in a water-soaked condition, it should not be permitted, on the other hand, to become thoroughly dry. The sap in the trees would be likely to dry out and the bark shrivel if this should occur. Difficulties of this sort can be avoided easily by the judicious application of water.

Berry bushes and other small fruits are handled in essentially the same manner as trees, but the trenches in which the roots are placed are shallower than for tree fruits, to correspond with the size of the plants.

PLANTING THE TREES AND OTHER NURSERY STOCK

The most satisfactory time for planting fruit trees and bushes in eastern Colorado in the average season is the last of April or the first of May. The soil is usually in good workable condition at this time, and as a rule it is a period during which there is considerable precipitation. These conditions are favorable for growth, and if a tree or other plant reestablishes itself readily in its new place and growth begins promptly one of its most critical periods is past.

The best time for planting fruits in the other parts of the Great Plains area may vary somewhat from the dates for Colorado given above. Generally, it may be done earlier in the southern sections and later in the north. It should be done after the danger of hard

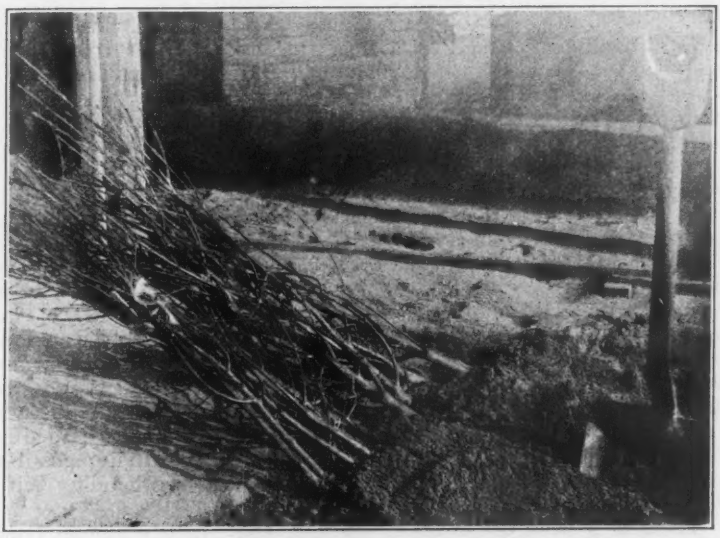

FIG. 3.—Peach trees heeled in. The position in which the trees are placed is to be noted

freezing temperatures is past and when the soil is in good condition for working; otherwise, the earlier the better, usually.

The method of planting fruit trees in this area does not differ in any essential from that commonly followed in other parts of the country. In handling the trees every possible precaution needs to be taken to prevent the roots from becoming dry when the trees are removed from place to place. The roots should not be exposed to the air more than is absolutely necessary. Covering with wet burlap is, perhaps, the most convenient means of giving protection, but wet chopped straw, damp moss, or other materials that can be moistened and covered over the roots may be made to serve the purpose; or the roots may be protected by puddling them. This consists merely in dipping the roots in a puddle of clay. The clay should be of such consistency that a thin layer of mud will adhere to the roots when they are dipped into it and at the same time per-

mit them to be moved about in it with perfect ease and freedom. Such a coating of mud will afford considerable protection against undue drying out from exposure to sun and wind. By observing this precaution at all times, including the period of exposure incident to planting the trees, there should be no loss due to dried-out roots.

The holes are made broad enough to receive the roots without bending them from their natural position and deep enough so that when filled even with the surrounding surface the trees will stand 2 or 3 inches deeper than they did in the nursery. Sometimes the holes are made in the fall, as previously described.

Before planting, the ends of all broken roots and roots otherwise injured should be removed with a smooth cut. As the trees are placed in position in the holes the soil is carefully worked around the roots and firmly packed by tramping. If the soil is moderately moist it will not be necessary as a rule to water the trees when planted; but if the soil is dry it may be well to pour a pail or two of water into the hole after it has been partially filled with soil, and then complete the filling after the water has soaked in. The subsequent use of water should be governed by conditions. If it continues dry after the trees are planted an occasional application of water sufficient to keep the soil in the vicinity of the roots well moistened may enable the trees to grow readily when otherwise they might fail entirely from lack of moisture.

When the trees are planted they should be headed back to the desired height. It is believed from experience and observations under Great Plains conditions that the main stem or trunk of the tree should not exceed 2 or 2½ feet in height, measuring from the surface of the ground after the tree is planted. In many cases the heads may well be formed even lower than this. Trees with low heads are not as likely to be injured by sun scald as those with high heads, nor are they as much affected by the wind. If the trees have been headed in the nursery, as is the case with stock 2 years old, it is often impossible to handle them so as to place the heads at the desired height. With 1-year-old trees this difficulty does not exist.

There is a wide difference of opinion and practice among fruit growers as to the details to be observed in shaping the permanent head of the tree, but the conditions attending tree growth in this area are such that it is believed an open head which develops from a few main branches is preferable to one so managed that it becomes dense and bushy.

To develop an open head, only four to six branches should be left when the tree is pruned at the time it is planted, or when it is formed later if 1-year-old trees have been used. These branches should be selected with a view to their position on the trunk. They should be arranged symmetrically and spirally about the trunk and should start from different levels, thus leaving some space vertically between the different limbs. If two limbs branch from the trunk at the same level there is much more danger that they will split down in later years under the weight of a large crop of fruit or during a heavy wind than where the formation is as here suggested.

The branches selected for the permanent top of a 2-year-old tree should be cut back considerably at the time the tree is planted. If the

tree has made a fairly vigorous growth in the nursery the preceding season, one-half or two-thirds of the length, as a rule, may be cut away. This will tend to make the branches strong and stocky rather than slender and "leggy," as when no cutting back is done.

This plan of forming the head also reduces the number of branches which the roots are required to supply with moisture during the first season's growth. It should be kept in mind that a considerable portion of the root system is lost in digging the tree from the nursery and that the branches need to be reduced proportionally.

The plan described is illustrated in Figure 4 and still further shown in Figures 5 to 10. Figure 4 shows a McIntosh apple tree in July of its second season's growth in the Akron fruit garden. It was headed low, the number of permanent branches was reduced to four or five, and from the very beginning the top has been kept open. The same plan of development may be seen in the other illustrations mentioned.

FIG. 4.—A McIntosh apple tree in July of its second season's growth, which has been pruned with a view to developing an open head. Akron, Colo.

The method followed in planting small fruits is essentially the same as that described for tree fruits. They are planted, as a rule, a little deeper than they were originally. They are cut back, if necessary, to make the tops correspond to the root system, and in other respects the directions given above are readily adapted to handling small-fruit plants.

Because the roots of small fruits are nearer the surface than those of tree fruits it may be necessary to give more attention to watering newly set plants until after they start into growth than is suggested for trees. This applies with special emphasis to strawberries.

PROPER DISTANCES FOR PLANTING

The distance between fruit trees is a matter of greater importance than is commonly realized. The space unoccupied at the time the small trees are planted seems out of proportion to their size, but the

requirements when the trees are mature must be anticipated. It should be remarked that the roots extend very much farther than the spread of the branches, contrary to a commonly expressed notion. At Cheyenne Wells, Colo., the roots of a 14-year-old apple tree were traced 26 feet in one direction from the tree and some 9 or 10 feet in the opposite direction, making a spread of at least 35 feet; in fact, the actual spread was several feet more than this, as it became impracticable to trace the roots in the very dry, hard soil to their ends.[2] The great number of roots that develop on apple trees under semiarid conditions is suggested by Figure 11, and the expanse of the roots is shown in Figure 12. It was 26 feet from the stump to the

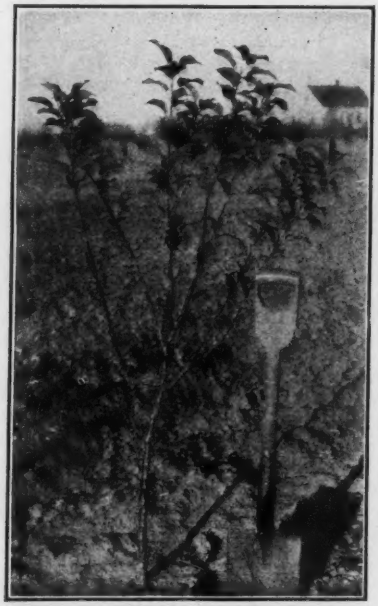

FIG. 5.—A Delicious apple tree after two seasons' growth as it appeared before its annual pruning. The foundation for the top consists of four or five main limbs

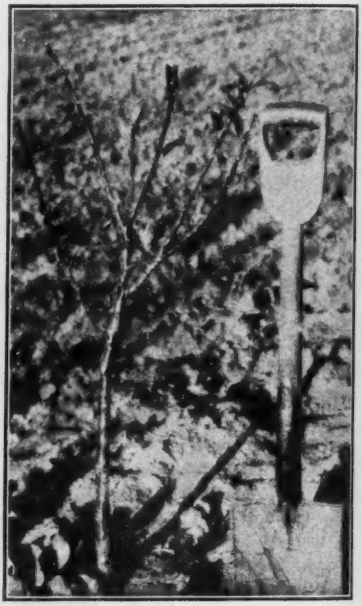

FIG. 6.—The Delicious apple tree shown in Figure 5 after being pruned. Both figures were reproduced from photographs taken at Akron, Colo., in November

end of the root held by the man shown on the left in the illustration (fig. 12).

It therefore appears that trees in their earlier life may suffer more from the crowding of the roots than from the crowding of their tops. The bearing which these facts have on the welfare of the trees is largely in relation to the moisture supply. If the trees are too close together their combined moisture requirements may exceed that furnished by normal precipitation.

[2] This study of the root systems was made in August, 1910, at the Dry-Land Substation of the Colorado Agricultural Experiment Station by J. E. Payne, then connected with that station, and one of the writers. For further details, see Payne, J. E., "Notes on a dry-land orchard," Colo. Agr. Exp. Sta. Bul. 173. 1910.

Too close planting is a common fault in many of the commercial fruit-growing districts in irrigated as well as in humid sections. Its results in semiarid sections where irrigation is not practiced are likely to be particularly serious.

Although fruit trees may not grow as large under the semiarid conditions of the Great Plains as in humid sections, it is not believed that this fact is sufficient to warrant close planting. On the other hand, the size attained here by trees is likely to be governed very largely by the amount of moisture available.

In the light of the foregoing statements, the following distances each way for the planting of different fruits are suggested:

Apples, 30 to 35 feet.
Pears, 25 to 30 feet.
Peaches, 20 to 25 feet.
Plums, 20 to 25 feet.
Cherries, 20 to 25 feet.
Sand cherry-plum hybrids, 10 to 15 feet.
Currants, 5 to 6 feet.
Gooseberries, 5 to 6 feet.
Raspberries, 6 to 7 feet.
Blackberries, 6 to 7 feet.
Strawberries, usually in rows 3 or 3½ feet apart, with the plants 1½ to 2 feet apart in the row.

FIG. 7.—The same Delicious apple tree shown in Figures 5 and 6 as it appeared in July of the following season. The buds near the ends of the stubs in Figure 6 have developed into branches, thus making a good framework for the development in the future of a strong, well-branched tree. Akron, Colo.

Many of these distances may seem excessive at first, but they allow none too much space when the demands of mature trees and other plants for moisture and plant food are taken into account.

TILLAGE

The tillage (or cultivation, as it is more commonly termed) of a fruit garden or orchard in this region should be very thorough. Its primary objects are to maintain the surface of the soil in a fine granular condition, so that it will readily absorb all of the rainfall, and to prevent the growth of weeds. A fine dust mulch does not take up the moisture as freely as a granular surface does.

The other objects of tillage will generally follow as a matter of course. Usually it should be continued fairly late in the season.

During one year seasonal cultivation in the dry-land ranch garden at Akron was discontinued early in August in order to avoid further stimulation of growth and to insure a thorough ripening of the wood before the advent of cold weather. However, no beneficial results followed that could be attributed to the cessation of cultivation as early as this; and, besides, it might prove a rather hazardous plan in some seasons. The growth of weeds following the cessation of cultivation so early in the season was sufficient to make a serious drain on the supply of soil moisture. The danger lies in the fact that the moisture in the soil might be reduced

FIG. 8.—An Utter apple tree after its third season's growth as it appeared before its annual pruning. In previous years the pruning has been directed toward keeping the top open

FIG. 9.—The Utter apple tree shown in Figure 8 after being pruned. Both illustrations (Figs. 8 and 9) were reproduced from photographs taken at Akron, Colo., in November

to such an extent that the trees would suffer during the winter or the following season in case there was little precipitation.

Tillage in the garden at the United States Dry-Land Field Station has been frequent enough to destroy weeds before they have made any considerable growth, to prevent the soil from blowing, and to insure against any run-off during heavy showers. To these ends the surface has been kept in a rough, granular condition. In accomplishing these objects, the soil moisture has been well conserved against evaporation from the surface. Tillage has usually been continued until the latter part of August, or late enough to prevent any considerable growth of weeds and to avoid all danger of their going to seed.

This practice with regard to tillage has given good results in the Akron garden. Moreover, in its general principles it has been followed by ranchers in other sections of this area in the successful growing of fruit. Slight modifications of this plan of tillage may be necessary under some soil and climatic conditions, but it is believed that it embodies the essential features, so far as this operation is concerned, in maintaining orchards and fruit gardens in this area, not only while they are young but after they reach maturity.

Clean tillage throughout the season during the early life of an orchard amounts practically to summer fallowing. During the first three or four years and before the roots have extended very far, the demands made by the trees upon the soil moisture are comparatively small. With normal precipitation the tendency obviously would be for the percentage of soil moisture in the spaces between the trees to increase rather than to decrease under this method of management. In this way, the greater demands of the trees for moisture as they reach larger size are anticipated in a measure, at least for a time.

FIG. 10.—The same Utter apple tree shown in Figures 8 and 9 as it appeared in July of the following year. Akron, Colo.

Cover crops and green-manure crops serve a most important purpose in maintaining the fertility of orchard soil in humid and irrigated sections, but in this area where the soil moisture is so largely the limiting factor their use rarely, if ever, can be advised. The growing of these crops usually would draw so heavily upon the moisture in the soil that they would be a menace rather than a benefit to the fruit. The humus furnished by such crops in sections where they can be grown must be supplied here by applying manure or vegetable matter in some other form.

For a similar reason the interplanting of crops between the rows of trees in young orchards, as is commonly done in commercial fruit-

growing sections, can not be recommended in this area. In the case of apple trees planted 30 or 35 feet apart, a row or two of corn or some vegetable possibly could be planted for the first two or three years midway between the rows of trees without irreparable harm to the latter, but the wisdom of even this limited competition with the trees would usually be doubtful.

The tools used in cultivating fruits may be a disk harrow, corn cultivator, or shovel cultivator, as conditions or convenience may dictate. While there are specially constructed orchard-tillage implements, the same tools used in the cultivation of general crops may be used advantageously in most cases.

FIG. 11.—Part of the root system of a 14-year-old Ben Davis apple tree. Colorado Experiment Station, Plains Substation, Cheyenne Wells, Colo., in August

PRUNING

There is probably no phase of fruit growing on the Great Plains which requires greater care and attention in order to obtain the best results than the operation of pruning. Although this is especially true of tree fruits it is also of importance with small fruits.

One of the commonest faults to be found with fruit trees on many ranches in the Great Plains area is the density of the tops. This fault, however, is not more characteristic of fruit growing in this area than it is in many other parts of the country. It is a natural consequence in the first place of planting trees without properly forming the heads at the time they are set out and of improper pruning or no pruning at all in after years. In fact, as will be illustrated later, it is often practically impossible to correct the faults incident to improper pruning at the time of planting by pruning when the trees are several years old.

If only a single idea were to be kept in mind in pruning a fruit tree throughout its life, that idea might well be to keep the top sufficiently open to admit air and sunshine freely. If this is accomplished, most of the other objects for which fruit trees should be pruned will also be realized.

The fear that the branches will be injured by exposure to the sun is frequently offered as a reason for allowing the tops to become very dense. It is true that where a large limb which has been shaded continually is suddenly exposed to the direct rays of the sun serious injury may result, but when a tree is grown from the beginning with an open head and is properly pruned there is little danger from this cause.

In further understanding the principles of pruning, the reader will be assisted by reference to the accompanying illustrations, most

FIG. 12.—The same stump of a Ben Davis apple tree shown in Figure 11. The roots were traced a distance of 26 feet on the left and 9 or 10 feet on the right. The small extremities of the roots, amounting probably to several feet in length, still remained in the soil

of which are made from photographs taken in the Akron fruit garden.

Figure 4, previously referred to in connection with the planting of trees, shows also the pruning which was done following the first season's growth. The limbs were cut back to the points just below the level of the upper part of the spade handle, where the secondary branching may be seen. Branches which may have crossed each other and other superfluous growth were also cut out. While the top is open, it will be observed that the main limbs are well protected by leaves that developed from short spurs or buds. In a very dense top there would be but little development of leaf-bearing spurs along these limbs. The photograph reproduced here was taken in July. A good strong current season's growth is evident. This growth would normally be headed back during the following dormant season, and such thinning out as might seem necessary to maintain the top in a well-opened condition would be done at the same time.

Figure 5 shows a Delicious apple tree that was planted in the spring. The top was lightly pruned in July of the same year, the superfluous branches being removed. This figure shows the tree as it looked in November of the following year. The current season's growth of some of the branches was 2 to 3 feet, with practically no side branches. Figure 6 shows the same tree after it had been pruned. The results of this heavy heading back in November become apparent by reference to Figure 7, which shows the same tree the next July.

The strongest growth has taken place from buds near the ends of the stubs of branches shown in Figure 6. This is resulting in a well-proportioned stocky tree, yet one which can be kept well opened to the air and sunshine with a minimum amount of pruning. Had this tree been left, as shown in Figure 5, without heading back, the branching the next season probably would have occurred from buds near the ends of the branches, thus making a top of long, slender, "leggy" limbs instead of the compact framework that is seen developing in Figure 7. Perhaps this tree is not quite as tall now as it was in Figure 5 before it was pruned in November, but it is more stocky and in better shape for its future development than it would be if it had not been headed back.

Figures 8 and 9 illustrate still further the idea expressed in Figures 4 to 7 with reference to developing trees with stocky open tops. These show an Utter apple tree that was planted in the spring. The photographs from which these illustrations were made were taken in November two years later, before and after pruning. The tree had then completed three seasons' growth. From the beginning, it has been handled with a view to keeping the top open. As may be seen from Figure 8, in comparison with Figure 9, it was necessary to remove but little wood at this pruning, even though the current season's growth had been very strong, many of the limbs having increased 2 feet or more in length. The tree was started with a framework of four or five branches. With these as a foundation and with a small amount of corrective pruning each year the tree remains under easy control.

In contrast with the average apple tree to be found in this area, the one shown in Figure 9, as it here appears, may seem to many to be entirely too open. During the next season, however, the development of leaves and many small side branches, which may be expected eventually to form fruit spurs, causes the tree to present a very different appearance, as shown in Figure 10. As seen here it is in its fourth season's growth. It will not be headed back very much in the pruning which it receives in the future. Heavy heading back tends to stimulate additional wood growth. This tree has now been well shaped. The limbs that form the framework of the top, as well as the trunk, are stocky and strong. It is in good condition to begin to bear fruit. There is, therefore, no further need of pruning to encourage additional wood growth, but more or less thinning out of the top probably will be necessary each year. Slight heading in at times may be advantageous, but the foundation work, so far as pruning is concerned, has now been completed.

The keeping of the top well opened during the first few years is favorable for the development of spurs and short branches along the

limbs, thus tending to the production of a large bearing surface. It is on such growth that many fruit buds subsequently develop. This so distributes the fruit on the main limbs that there is the least possible danger of their breaking from its weight.

It should be stated, however, that there is much yet to be learned about the effect of heading back the annual growth year after year. If trees with strong stocky limbs are to be developed, rather heavy heading in for several years after planting seems as a rule to be necessary. On the other hand there is considerable evidence that if this practice is carried too far it very materially retards the time of bearing. Moreover, in this respect, it seems probable that trees of different varieties should be handled differently. Some varieties naturally make a strong stocky growth and do not branch excessively, while others develop long, slender branches. Obviously these two types of trees should be treated differently with respect to pruning.

FIG. 13.—A Wealthy apple tree planted in the spring, which received no further pruning until after its third season's growth. Because of these years of no pruning it was not possible in later years to bring the top to a desirable form. Akron, Colo., November

It is, of course, desirable that a tree should come into fruiting as early as possible after it is planted, but the gain of a year or two in earliness of bearing is of small importance compared with the development of a type of tree which in later years will best meet the ends for which it is grown. It is the nice balance between earliness of bearing and other characteristics and the development of a tree which in the long run shall be best suited to fulfill the ends in view that constitutes the real problem in pruning during the early life of an orchard.

In rather strong contrast to the trees shown in Figures 4 to 10 are those in Figures 13 to 17. The latter illustrate apple trees that were planted in the spring. The photographs used in making

these illustrations were taken in November after the trees had completed their seventh season's growth. Because these trees are considerably older than those shown in Figures 4 to 10, the illustrations in the two groups are obviously not entirely comparable. Yet they show certain contrasts that are of fundamental importance in pruning fruit trees at the time of planting and during the first three or four years thereafter.

In contrast to Figures 4 to 10, Figures 13 to 17 show apple trees that were not trimmed with any particular ideal in view when they were planted, and they received no further pruning until after they had completed their third season's growth. After that time they were pruned each year. To the casual observer the objectionable features of these trees may not be conspicuous, but they become very real to one who wishes to prune them in a rational manner.

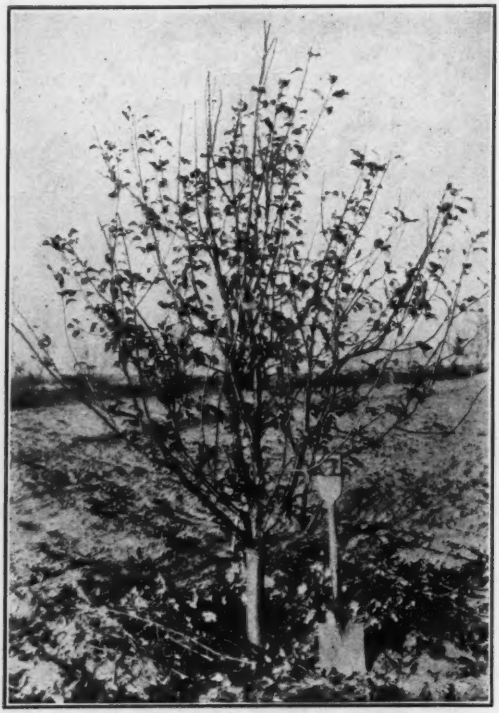

FIG. 14.—The Wealthy apple tree shown in Figure 13 after being pruned. Akron, Colo., November

Figures 13 and 14 show a Wealthy apple tree and Figures 15 and 16 a Patten tree in November, before and after pruning. Figure 17 is a Northwestern Greening apple tree not yet pruned. It will be seen by reference to the figures showing the trees before pruning that the tops are not extremely dense, as at the time the photographs were taken a good deal of the foliage had dropped. When the pruning was begun after three years of unrestricted growth, the tops of these trees were veritable heaps of brush. The pruning after the third year of growth was directed primarily toward the gradual removal of superfluous wood. However, because of the fact that the trees were not well formed at the time they were planted and during the first year or two thereafter, the pruning in subsequent years has failed and must continue to fail to reduce the work to the simple systematic operation that it is in the case of trees that are well pruned from the beginning. Most of the branches in these three trees (figs. 13, 15, and 17) are relatively long

and slender because they radiate so largely from a common axis or nearly from a common center. To keep the tops suitably pruned is difficult. If one of the larger limbs with its component branches is removed to open the top, the result is an unsymmetrical head; one side is made considerably lighter than the other.

The alternative in maintaining the tops sufficiently open for the free access of sunshine and air is to cut away a considerable number of the smaller branches. This tends toward the development of long slender unbranched limbs, with the bearing surface a little later in the life of the trees occurring only near the extremities.

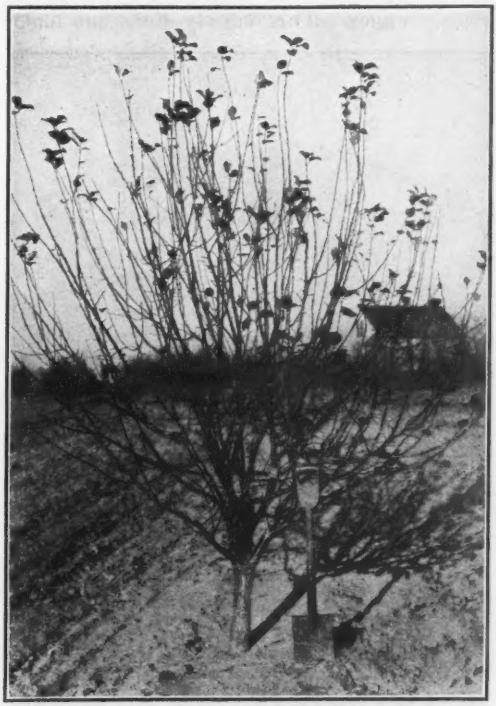

FIG. 15.—A Patten apple tree planted in the spring, which has received treatment similar to that of the Wealthy apple tree shown in Figure 13. Akron, Colo., November

The point in question is especially evident in Figure 17, where the tendency to make long slender growth is very conspicuous, in spite of the effort made during three or four years to put the tree into the best shape that its condition permitted.

A study of the illustrations here used emphasizes the fact, which all fruit growers recognize, that the natural habit of growth of different varieties must be considered in intelligent pruning. The upright habit of the Wealthy tree (figs. 13 and 14) and the roundish form of head shown by the Patten (figs. 15 and 16) and the Northwestern Greening trees (fig. 17) make the problem of pruning these two types quite different in each case, even though the principles involved are the same. The Utter tree in Figure 8 shows still another type of growth in that, even if left entirely unpruned, the top would not be likely to become as dense as that of the other varieties illustrated, because it does not branch so profusely. It is therefore less trouble to keep it well pruned, though the principles are the same as in pruning trees of the more profusely branching type.

The manner of pruning other fruit trees does not differ in principle from that followed with apple trees. Ordinarily the tops of

plum and cherry trees are not kept quite as open as apples, principally because of the greater natural tendency to form fruit spurs along the branches; but if due attention is not given to the proper forming of the tops when planted and to wise pruning subsequently, the same troubles as those detailed for apples are sure to follow. This fact is made evident by Figure 18, showing a native plum tree six years after being planted, which formed a head so dense that it was only with considerable difficulty that the fruit on the interior of the tree could be picked. Figure 19 is a Desoto plum tree a year younger. This variety does not make naturally as dense a growth as does the one in Figure 18; besides, it was planted one year later, so that it began to receive systematic pruning that much earlier in its life. These plum trees were headed back to some extent during the three or four years before they were photographed, but they will not be likely to require very much more heading back.

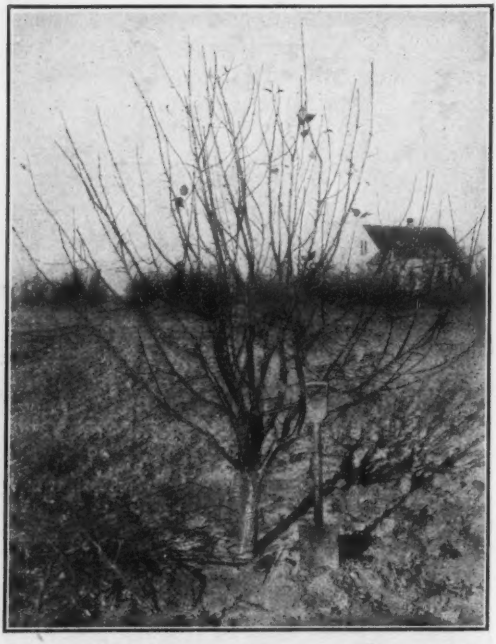

FIG. 16.—The Patten apple tree shown in Figure 15 after being pruned. Akron, Colo., November

The Early Richmond cherry tree in Figure 20, the same age as the Desoto plum, has responded fairly well to the corrective pruning that it received after it was 3 years old.

Another problem in pruning is suggested by the tree shown in Figure 21. In some parts of the Great Plains area rather strong winds blow much of the time. The influence of such winds can be more or less checked as a rule by growing a well-arranged system of shelter belts that extend across the path of the prevailing winds. A little can be accomplished also by pruning. The branches should be kept well headed in. This heading in may need to be done during the growing season if a long slender growth is being developed and it is being continuously forced far from its normal position. The top, if kept well opened, will offer less resistance to the wind than where it is allowed to become dense. Besides, if the tops are not too dense the branches will probably be less impeded in resuming their normal positions when the wind is

not blowing. However, a complete counteracting of the influence of strong prevailing winds is hardly to be expected except as the force of the winds is broken by shelter belts of some kind.

Great emphasis has been placed on pruning with a view to keeping the tops open. There are other reasons why systematic annual pruning should be done. Without regard to the order of relative importance, the more evident reasons may be enumerated as follows:

(1) Every branch is reaching out for sunlight. If the top is sufficiently open so that every leaf receives its full complement of sunshine there is less competition among the different branches than where the top is very dense.

(2) With the decreased struggle for existence among the branches, the crowding of the weaker ones and the resulting dead wood in the top of the tree are largely eliminated.

(3) The development of fruit-bearing spurs well within the center of the tree is encouraged because they receive sunlight, and sunlight in full measure is essential to healthy, vigorous growth.

(4) When a tree reaches bearing age it can be sprayed thoroughly, and it is evident that spraying will be necessary in this area if good fruit is to be grown. Besides, the fruit can be picked with reasonable ease and comfort. But not so if the picker must crawl through a brush pile to reach it.

(5) The above reasons are common to all fruit-growing regions. Another is of special significance on the Great Plains because of the limited rainfall. The conservation of the moisture in the soil is of the greatest importance. Great quantities of moisture are taken up by a tree and given off through the foliage. In general, the greater the amount of foliage the more rapidly is moisture given off. By proper pruning and thereby the holding of the top to a form or condition as to the number of branches and the amount of foliage which are most consistent with the objects for which the tree is desired, the less will be the loss of moisture from the soil through the foliage. Hence, it follows that wise pruning helps to conserve soil moisture.

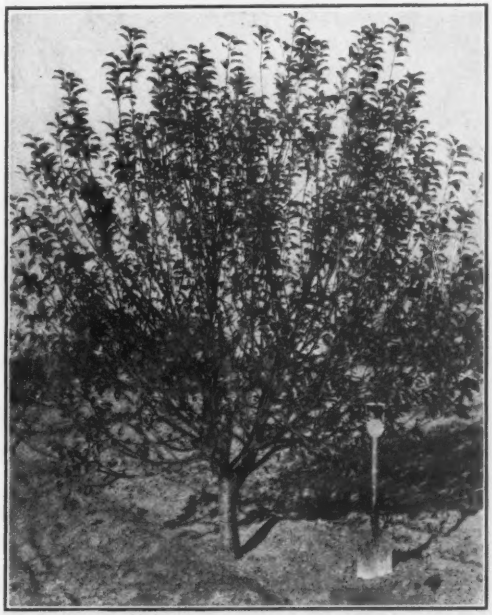

FIG. 17.—A Northwestern Greening apple tree planted in the spring, which has received treatment similar to that of the Wealthy apple tree shown in Figure 13. This is the largest apple tree in the garden. Akron, Colo., November

IRRIGATION

Although fruit growing on the average ranch in the Great Plains area must be largely under dry-farming methods, a relatively small quantity of water for irrigation may sometimes save fruit trees,

and especially strawberries and other small-fruit plants, during a particularly dry period.

Wells of large capacity and windmills are to be found on many ranches and often furnish an adequate supply of water for use in tiding fruits over a crisis of drought. On other ranches a supply of water for emergency use is sometimes stored in earth reservoirs, as suggested in Figure 22.

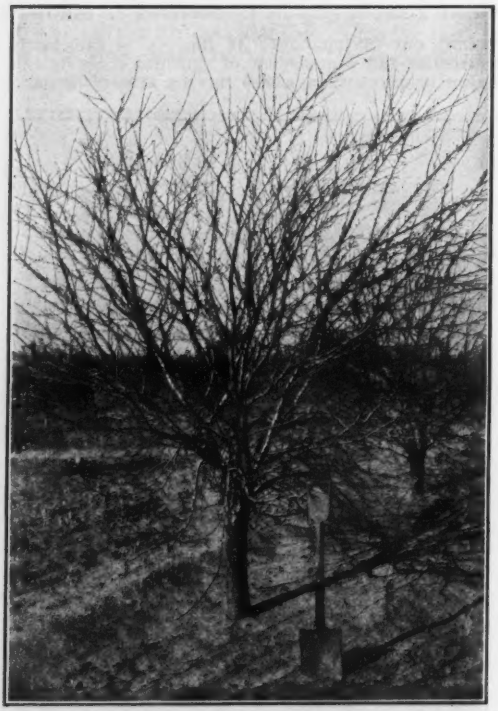

FIG. 18.—A plum tree of unknown identity planted in the spring, which is the largest tree of any kind in the garden, though during the growing season six years after planting the apple tree shown in Figure 17 nearly overtook it. It has received treatment similar to that of the Wealthy apple tree shown in Figure 13, but it is in better shape for a plum than the Wealthy is for an apple. Akron, Colo., November

Such a reservoir is made by excavating the earth and mounding it up somewhat about the edge or rim. The inside is then puddled with clay or in some other way made sufficiently impervious to water to prevent seepage. Obviously, it should be located if possible on a slightly elevated site. It may be filled from the ranch well when the water is not required for other purposes, and the water may be siphoned out when wanted for irrigation.

ORCHARD PESTS

The orchard pests in the Great Plains area are not known to be essentially different from those in other regions except as they are influenced by regional, primarily climatic, conditions.

On account of the comparative dryness of the atmosphere, fungous diseases are not as prevalent as in the humid regions, where conditions are more favorable for their development.

Insects, such as the codling moth and currant worm, may be expected to occur. It may be assumed that the methods of control that are effective in other regions will be equally effective in this area.

Rabbits are likely to injure young trees during the winter by gnawing the bark, and in some sections pocket gophers and prairie dogs may be troublesome. Information regarding the control of

these pests can be obtained by addressing the Department of Agriculture.

Sun scald sometimes occurs during the winter on the south or southwest side of the trunks, especially in the case of high-headed trees. Injuries of this kind can be prevented by shading the trunks in some way during the winter. Binding laths, narrow strips of board, or cornstalks about the trunks, or even wrapping them with newspapers, will furnish all the protection needed. The material used should be removed in the spring.

HAIL INJURY

The trees in the Akron fruit garden were once seriously injured by a hailstorm. The results may be of interest in connection with the handling of trees in other parts of this area which may be injured by hail. The oldest trees in the garden were completing their third season's growth when the storm occurred. The bark on the north side of the trunks and larger limbs of many of the trees was badly bruised, and in some instances practically torn from the trees. Nearly all varieties of apples and cherries sustained substantially the same degree of injury. There were several varieties of apples, however, that appeared as if by chance to escape in a slight degree, but it is hardly to be assumed that this was due to any greater resistance of these particular sorts to the hail. Most of the plum trees passed through this storm with relatively less injury than that received by the apple, pear, and cherry trees. The tops of the peach trees were practically killed.

FIG. 19.—A Desoto plum tree planted in the spring which has received treatment similar to the other trees, but as its tendency to branch is less pronounced the top never became as dense as some of the other sorts. Akron, Colo., November

During the two years following this injury the tops of a good many of the apple trees died, and to some extent those of other kinds also. The seriousness of the wounds on the trunks became very evi-

dent. In many instances where the tops were injured beyond recovery, good strong sprouts developed from some point along the trunks. The one best suited for renewing the top was selected and the original top cut away.

The results which followed such serious hail injury have made it clear that the wiser course as a rule is to dig up and discard trees that show severe damage, especially where they have been planted only two or three years. If they have reached bearing age, or nearly so, it may be worth while to do everything possible to aid the trees in outgrowing the injuries.

The hailstorm referred to was the only one that caused injury of any consequence in this garden during an 8-year period.

FIG. 20.—An Early Richmond cherry tree planted in the spring, an example of a tree that did not receive proper pruning and shaping of the top the first two years, but which responded fairly well to corrective pruning during the next three or four years. Akron, Colo., July

FRUIT VARIETIES SUGGESTED FOR PLANTING

Although the cultural methods used in fruit growing in this area have much to do with the measure of success that is attained, they are not more important than the selection of varieties that are adapted to the conditions. In fact, the choosing of the best varieties, especially of the tree fruits for planting in the different sections of the area is really more of a problem than to determine what methods of culture to adopt. This is true in a measure with regard to every region in which fruits are grown. But where the conditions, as in this area, are especially trying and present at best but a rather narrow margin between possible success and prohibitive limits, the problem of varieties becomes especially acute.

As mentioned in the discussion of the climatic conditions, the limited moisture, relatively low temperatures, and, in some parts of the area, a good deal of wind which increases evaporation make a combination of climatic influences that is very trying to fruit trees.

Not all varieties will do equally well throughout the Great Plains. In the southern part of the area the winter temperatures are much milder than they are in the north, but the wind is a more serious factor in the south than in the north. The very low winter temperatures reached in the north make it possible to grow only the fruits that have a high degree of resistance to cold.

Although very much yet remains to be determined with reference to the adaptability of varieties to the Great Plains area, it is believed that the mention of a number of different fruits which have been planted more or less may be suggestive and of some help to those who are without experience in choosing varieties to plant in this part of the country.

APPLES

Southern section.—A few of the varieties of apples that may well be considered for the southern part of this area are the Yellow Transparent, Red June, San Jacinto, Maiden Blush, Gravenstein, Wealthy, Grimes Golden, Jonathan, Kinnard, Northwestern Greening, Texas Red, Winesap, Missouri Pippin, Arkansas Black, Ralls, and Limbertwig; for crab apples, the Florence, Hyslop, and Dartt. These varieties, named approximately in the order in which they mature, represent a long sequence of ripening, from the early to the long-keeping sorts.

FIG. 21.—A Northwestern Greening apple tree planted in the spring at the Amarillo Cereal Field Station, Amarillo, Tex., as it appeared in July four years later. The prevailing winds have blown so incessantly as permanently to force the branches to grow largely in one direction, thus making an unsymmetrical top

Central section.—Most of the varieties that succeed best in the southern part of the area could doubtless be planted in the central section. However, the behavior of the fruits in the garden at the Akron Field Station may be used to further the information concerning varieties in this part of the area, at least so far as the growth of the trees is concerned. Reference to the various illustrations in this bulletin showing apple trees in this garden will be of assistance in this connection.

Among the apple trees in the garden that have made a good growth are the following varieties: Yellow Transparent, Oldenburg, Wealthy, Northwestern Greening, Patten, McIntosh, Jonathan, Longfield, Grimes Golden, Utter, Okabena, and several others; also the Hyslop, Virginia, and Florence crabs. Some of the newer apple varieties considered promising are: Anoka, Haralson, and Erickson, also the Dolgo crab.

These varieties appear to be sufficiently hardy to withstand the normal conditions in this region, but thus far they have been disappointing in fruit production. Though old enough to bear considerable fruit as compared with other sections, they have produced very little here.

A number of dwarf apple trees were planted during the first year or two following the establishment of the garden. These include the Yellow Transparent, Oldenburg, Gravenstein, Wealthy, Bismarck, McIntosh, Esopus Spitzenburg, and Northern Spy. Thus far these trees have done well, and their behavior is such as to make them seem rather promising. Dwarf apples can not be recommended for planting, however, until after they have more definitely demonstrated their value.

FIG. 22.—An earth "tank," or reservoir, for irrigating small gardens and fruit plantations

Northern section.—Naturally the varieties that can be planted in this part of the area must be restricted to the hardier sorts on account of the extremely low winter temperatures. These include the Oldenburg, Wealthy, Hibernal, McMahon, Northwestern Greening, Patten, Malinda, the Hyslop, Virginia, and Florence crabs, and possibly some others named in the Akron Field Station list for planting where the conditions are not too extreme; also the newer varieties suggested under the "central section" for trial. There are some localities in this section, however, where even the hardiest sorts would be of doubtful value.

PEARS

There are hardly enough pears now growing in this area to show the range of their possibilities, unless their comparative absence is to be interpreted as signifying that they are not well adapted to these conditions. The Kieffer, Duchess d'Angouleme (*Duchess*),

Bartlett, and possibly one or two other sorts are occasionally grown in the southern part of the area. A variety supposed to be the Warner has grown well at the Akron Field Station, but has produced only lightly. The Flemish Beauty is one of the hardiest sorts and sometimes succeeds farther north than most other varieties. Except in sections with more severe weather, the Sudduth, Tait, and Mendel are suggested for trial.

PEACHES

Peach growing in this area is largely confined to the southern section, where a considerable number of varieties are grown to a limited extent. These include the Alexander, Sneed, Triumph, Arp, Carman, Mamie Ross, Chinese Cling, Elberta, Heath Cling, General Lee, Lemon Cling, and others.

At the Akron Field Station peach trees, including a number of the hardier sorts, were killed to the ground, or nearly so, every winter.

PLUMS

Plums, particularly the native sorts, are among the most dependable of all the tree fruits on the Great Plains. They have been planted quite widely throughout most of this area, and there is a fairly large number of varieties from which to choose. Of these the following are named, especially for the southern sections: America, Desoto, Golden (*Gold* of Stark Bros.) Kroh (*Poole's Pride*), Pottawattamie, Six Weeks, Surprise, Wild Goose, Wolf, and Wyant.

Among the more promising varieties at the Akron Field Station are the following: Brittlewood, Emerald (*Burwood*), Cheney, Desoto, Surprise, Terry, Wolf, and Wyant. The identity of the plum shown in Figure 18 is unknown, but it is one of the most promising sorts in the Akron garden. It resembles the Brittlewood somewhat and may prove to be of that variety. Most of these varieties have been planted widely throughout the Great Plains area. Several varieties of European plums, including the Lombard, Arctic, Shropshire (Damson), and others, have also been planted at this station. None can be considered promising. The trees make only small growth as a rule, and do not satisfactorily withstand winter conditions.

In parts of the northern section the following varieties are grown more or less: Cheney, Desoto, Forest Garden, Surprise, Waneta, Wolf, and Wyant. Some comparatively new sorts that appear to merit testing are: Elliot, Red Wing, Tonka, and Underwood.

The native plum trees in the fruit garden at the Akron Field Station have not been very long lived as a rule. In fact, in nature where they occur in thickets, the perpetuation of the thickets is usually dependent largely on the growth of sprouts or seedling trees. The trees in the center, and others as they attain age, are likely to weaken and die. Therefore the grower should not be discouraged if he finds it necessary to replant plum trees every few years. It would probably be wise to make new plantings occasionally in anticipation of the loss of older trees through natural causes.

PLUM HYBRIDS

Among plum hybrids the Compass cherry, a hybrid between the sand cherry and the Miner plum, has been widely planted in this area. It is proving to be of distinct value. Trees planted at the Akron Field Station began bearing two years later and have produced fairly regularly. Though not of high quality, the fruit is very acceptable. The tree comes into bearing early and seems to be perfectly hardy at Akron. Figure 24 shows a Compass tree as it appeared in November four years after being planted. The tree makes a very open growth; practically no thinning out of branches has been done in the tree shown here.

A number of other sand cherry-plum hybrids and other plum hybrids have been planted. In general they are desirable for the Great Plains area, being hardy and seemingly well adapted to the conditions under which many other fruits fail. The Opata, Sapa,

FIG. 23.—Sand cherries planted in the spring, fruiting heavily two years later. Akron, Colo., July

Sansoto, Oka, Tom Thumb, Hanska, Waneta, and Radisson are considered the better known or more promising hybrid varieties.

CHERRIES

Of the tree fruits, sour cherries are perhaps of equal value with native plums for this area. The number of varieties commonly grown is small, the Early Richmond, Montmorency, and English Morello comprising nearly all the trees that have been planted; in fact, there are probably to be found many times more trees of a single variety—the Montmorency—than all the others combined. These varieties are successful generally in the central and southern sections, as well as in some parts of the northern section, but in the latter there are large regions where the conditions practically preclude the growing of cherries. The Zumbra, a recently introduced variety, is promising for some parts of the northern Great Plains. It is a supposed compound hybrid of a pin cherry, a sweet variety, and the sand cherry.

A 6-year-old Early Richmond cherry tree at the Akron Field Station is shown in Figure 20. Several trees of the Black Tartarian and other sweet cherries have also been planted at this station, but they have either died or are in an unsatisfactory condition. It is not believed that sweet cherries are likely to withstand the conditions anywhere in this area.

Sand cherries also do well in many parts of the Great Plains area. The ones shown in Figure 23 fruited two years after being planted. The fruit is of value primarily for making jelly or preserves rather than for use in the fresh state. But as the sand cherry is native to the Great Plains, doubtless selections could be made which would bear fruit of fairly good edible quality.

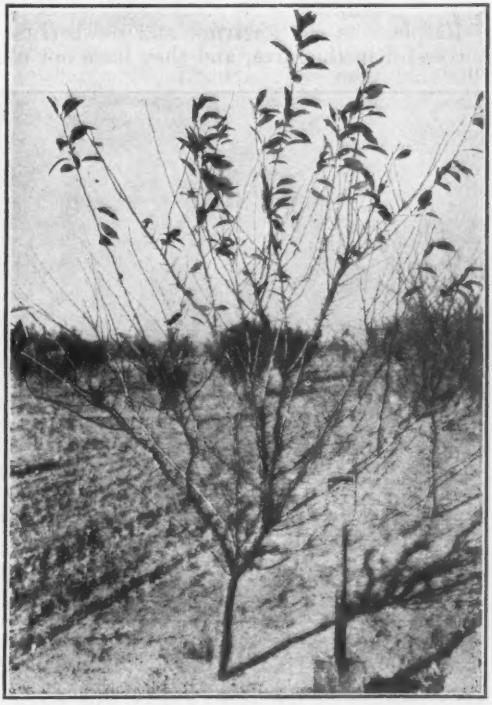

FIG. 24.—A Compass cherry 3 years old. The open spreading habit of growth is to be noted. Akron, Colo., November

CURRANTS

Currants appear to be one of the most satisfactory small fruits for the Great Plains. Most varieties do about equally well and are generally hardy. The London Market is perhaps grown in larger quantities than any other sort, but the Cherry, Victoria, Red Dutch and North Star, for red sorts, and the White Grape, for a white variety, have done well at the Akron Field Station and include the sorts most commonly found elsewhere in the Great Plains area.

The plants as a rule are a little slow the first year in getting started, but when well established they make a good growth if properly pruned. Figure 25 shows some currant bushes about 4 years old which are quite typical in growth of all the varieties at the Akron Field Station.

GOOSEBERRIES

In general, what has been said about currants is true also of gooseberries. They are quite dependable wherever currants are succeeding.

As in the case of the latter, the plants are a little slow in getting established and do not often make a very strong growth the first season. After they are once well established, they appear to be hardy. To keep them vigorous, however, the sprouts that habitually grow from the ground in rather large numbers should be kept well thinned out.

Probably the Downing, Houghton, and Poorman can be planted generally in this area with as much assurance of satisfaction as any other varieties.

RASPBERRIES, BLACKBERRIES, AND DEWBERRIES

Raspberries, blackberries, and dewberries have not proved very successful in this area, and they have not been planted as a rule in the ranch fruit gardens. Generally speaking, they do not withstand dry weather well. Even in the humid sections heavy losses sometimes occur as a result of drought.

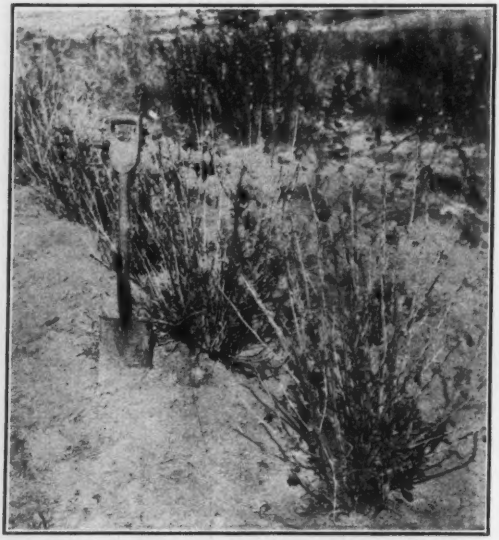

FIG. 25.—Currant bushes about 4 years old, showing typical growth, Akron, Colo., November

In many instances in this area the plants are slow in starting growth after being set out, though when once established the roots are quite persistent. The canes, however, are very apt to kill to the ground during the winter. To some extent winter injury can be prevented by bending the canes to the ground and covering them with soil, but how widely this method of winter protection can be used successfully is not definitely known.

Of the varieties observed in this area there seems to be but little, if any, real preference, as there has been no important difference in their behavior. Of the raspberries, the Cuthbert, Loudon, King, and Sunbeam, for red sorts, and the Cumberland, Kansas, and Winfield, for black varieties, have been planted at the Akron Field Station. They have all borne a little fruit; possibly the Sunbeam has done fully as well as any variety. The canes of all varieties have winter-killed so badly that there is little choice for planting. No winter protection, however, has been given them. The Latham is suggested for trial and the Chief is promising.

Blackberries at the Akron Field Station have behaved in essentially the same manner as the raspberries. They are rather slow to start into growth after planting. The canes have been killed back

to the ground, or nearly so, every winter, and practically no fruit has been produced. The Himalaya, a variety the canes of which are perennial and normally do not die after producing a crop of fruit, as do the ordinary varieties, has made a fairly strong growth each year. However, it is not hardy enough to withstand the winters, though it does not usually kill back as far as do the other sorts. It has produced a very small quantity of fruit, which ripens over a long period, and only a few fruits are ever ripe at the same time, even on 10 or 12 large plants. The berries are small and imperfect, merest nubbins, and the proportion of seed to pulp is so large as to make the fruit almost inedible. Besides the Himalaya, the Snyder, Mersereau, and Rathbun varieties have been planted, none of which seem to be promising for this area.

Only one variety of dewberry, the Lucretia, has been planted. This bore a little fruit one year, but in general its behavior has been the same as that of the raspberries and blackberries.

It is probable that much of the winter injury to these fruits is due to the limited moisture supply rather than to the direct effect of low temperatures, especially in the southern and central sections. In the northern part of this area extreme cold is doubtless a limiting factor in itself, except where the plants are adequately protected. To the extent that the difficulty is a matter of moisture, proper irrigation before the ground freezes in the late fall might be of considerable importance.

STRAWBERRIES

Success with strawberries in this area seems to be more largely a matter of the plants becoming well established and having an adequate moisture supply during certain periods than in the planting of any particular variety; in fact, the establishment of the plants is usually dependent upon a suitable amount of moisture in the soil. The roots are so near the top of the ground, at least until after growth has been well renewed, that they are very susceptible to the surface conditions of the soil. The roots of strawberries may dry out completely before a new growth starts, where other kinds of plants with their roots deeper in the soil would not be seriously affected. Hence, if newly set plants can be watered as needed until they are well reestablished after transplanting, the chief danger of failure in the beginning is eliminated. Unless this can be done, the plants will die in many cases before a new growth starts.

It is also important that water be available for use during the development of the fruit. At this period the strawberry requires a relatively large quantity of water. If it is lacking, the fruit will be small and much of it may fail to develop.

By mulching with straw during the winter to prevent repeated thawing and freezing as well as to protect the plants from extreme temperatures, strawberries can probably be grown almost anywhere in the Great Plains, provided water can be applied during the critical periods mentioned.

While irrigation might be quite advantageous at times in the growing of other fruits, it may often be practicable to water a small strawberry bed that can be located near the dwelling house, when it would be out of the question to water a fruit garden more or less distant from the buildings.

As to varieties, the Dakota and Dry Weather in the northern section, the Dunlap and Mastodon in the central, and the Klondike in the southern section are suggested.

MISCELLANEOUS BERRIES

Not many Juneberries have been planted in this area. As a rule they do not make a very vigorous growth, but appear to be hardy when well established and may be expected to bear considerable fruit. The fruit, while not of high quality, will add an agreeable variety for home use.

Of the wild fruits that are native to this area the buffaloberry is worth consideration, especially for the northern sections, where the range of fruits that can be grown is more limited than in other parts of the area. The fruit is small and very sharply acid. Its most important use is probably for making jelly, though it is eaten in the fresh state to a limited extent.

The fruit-producing blossoms are borne on separate plants from those that bear the pollen-producing blossoms. As only the former bear fruit, bushes for planting should be largely of that type, though a small proportion of the others must also be planted to supply pollen for the fertilization of the fruit-producing blossoms.

Selections of the highbush cranberry are suggested for the central and northern sections.

GRAPES

There is very little definite knowledge concerning the possibilities of grape growing in this area. Low temperatures in the north are largely prohibitive, but in some parts of the other sections it is probable that a measurable degree of success could be obtained, especially in localities where wild grapevines are found. Many varieties have been tested in recent years at certain of the dry-land agricultural field stations in the southern part of the area. Some of the varieties that have given promising results include: America, Beacon, Captain, Carman, Catawba, Delaware, Edna, Ellen Scott, Extra, Fern Munson, Headlight, Muench, R. W. Munson, and others. Beta and Alpha are hardier and can be grown farther north than most other varieties.

MIXED PLANTING ADVISABLE

Attention should be here called to the fact that many varieties of apples, plums, pears, cherries, and other fruits are more or less sterile with their own pollen. Such varieties, therefore, may be unfruitful, even though they blossom abundantly, unless planted in close proximity to other varieties of the same kind which blossom simultaneously with them. While not all varieties are self-sterile, and sometimes those which are so under certain conditions are not self-sterile under others, the matter is of too great importance to be disregarded when planting orchards or fruit gardens. It is therefore always wise to select at least two varieties of each kind of fruit for planting, unless one has good evidence that under his conditions a variety which he desires is self-fertile.

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GROWING FRUIT FOR HOME USE

IN THE GREAT PLAINS AREA

FRUIT GROWING in the Great Plains area is a home-making rather than a money-making unit in farm-ranch organization. However, anything that adds to the comfort, satisfaction, and well-being of the home often makes returns far in excess of the money value that can be placed upon it. Not all values of material things are money values.

Though the hazards of spring frost, drought, and other climatic factors in this area are too great to justify the planting of any kind of fruit with a view to its becoming a main money crop, there are few seasons when more or less of a yield of some kind—plum, cherry, currant, gooseberry, or other hardy fruit—can not be produced in most sections. An effort to have home-grown fruit every year is very much worth while. Whenever a fruit garden in this area produces a surplus, there need be no fear of an overstocked market to interfere with its ready sale at good prices. Not infrequently ranchers travel many miles to get fruit from some orchard that has developed a commercial surplus.

Although the general methods of fruit culture do not differ greatly in the Great Plains area from those in other sections, there are details of practice of peculiar importance and precautions which if fully observed may help to counteract some of the naturally adverse climatic conditions. The selection of varieties that are the best adapted to these conditions is also fundamental to success.

Washington, D. C.

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GROWING FRUIT FOR HOME USE IN THE GREAT PLAINS AREA

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CONTENTS

	Page		Page
Introduction	1	Proper distances for planting	11
Sites for fruit plantations	3	Tillage	13
Climatic features of the Great Plains	4	Pruning	16
Preparation of the land for planting	6	Irrigation	23
Nursery stock	6	Orchard pests	24
Handling the stock when received from the nursery	8	Hail injury	25
Planting the trees and other nursery stock	9	Fruit varieties suggested for planting	26
		Mixed planting advisable	34

INTRODUCTION

DURING recent years a transformation of large import has been taking place in the Great Plains area. From a vast territory devoted largely to the grazing of cattle and with a very small population it has become an area in which great quantities of grain and other crops are produced annually, with a corresponding increase in the number of homes. Though some sections are still very sparsely settled, the aspect of the entire area has been materially changed by the influx of people who have come from many different parts of the country.

The Great Plains area is not "a natural fruit country," as those regions in which native fruits abound or where the conditions are especially favorable for fruit production are often called. On the other hand, very few native fruits occur in this area, and comparatively little attention has been given to the planting of the cultivated fruits. However, many of the recent comers are from sections where they have been accustomed to grow what fruit was needed for home use. It naturally follows that in many instances upon establishing new homes in this area they have planted a few fruit trees. As a result there are numerous ranches widely distributed throughout the Great Plains where some attempts are being made to grow a home supply of fruit.

NOTE.—This bulletin is intended especially for those in the Great Plains area who are interested in growing fruit for home use, but some parts of it, especially the discussion about pruning and shaping trees, are of general interest to people living in other sections of the country.

The information is based largely upon the results obtained in a dry-land fruit garden which was established in 1908 at the Dry-Land Agriculture Field Station of the Bureau of Plant Industry, Akron, Colo. Most of the illustrations are from photographs taken in this garden.

This bulletin supersedes Bureau of Plant Industry Circular No. 51, entitled "Fruit Growing for Home Use in the Central and Southern Great Plains."

In a few instances orchards of some commercial importance have been developed. Most of these are the outgrowth of one or more of several conditions: (1) The location has proved to be exceptionally well suited to the growing of fruit; (2) the owner has had considerable experience in fruit growing before coming to this section; or (3) the owner, as he has gained experience here with a small orchard, has found himself better qualified for the details of fruit raising than the ranchers generally, and has gradually increased his fruit interests to good advantage.

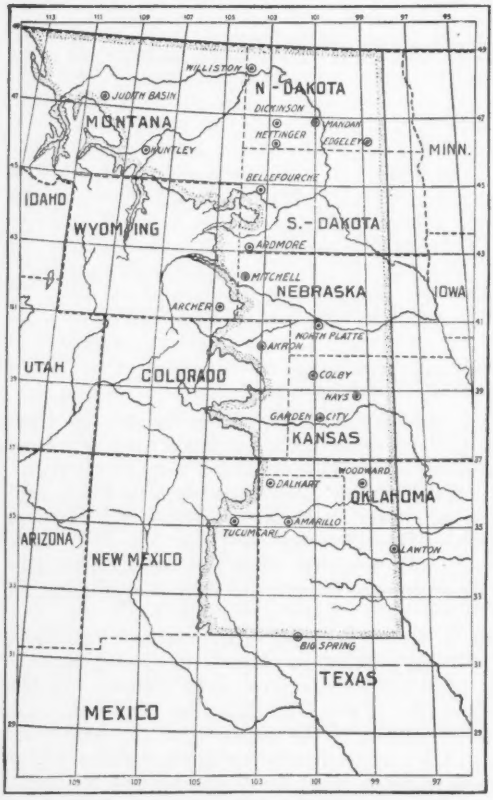

FIG. 1.—Sketch map of the Great Plains area, which includes parts of 10 States and consists of about 400,000 square miles of territory. Its western boundary is indicated by the 5,000-foot contour. Each dot within a circle (⊙) indicates the location of a field station of the Division of Dry Land Agriculture of the Bureau of Plant Industry

The surplus fruit from the home orchards, as well as that produced in those of larger size, always finds a ready sale, buyers sometimes driving many miles to obtain it.

Within the boundaries of the Great Plains area there are a few restricted districts that are under irrigation. In some of these, orchard interests of considerable commercial importance have been developed. These interests are not discussed, however, in this bulletin.

The tree fruits that occur most commonly in the dryland ranch orchards are apples, cherries, and native plums. In some of the milder parts of the area, especially in the southern section, pears and peaches are more or less common, while still less frequently apricots are found. Currants and gooseberries are probably the most important as well as the most common of the small fruits. Juneberries, buffaloberries, and strawberries are sometimes to be found.

The successes and failures in this area, as in other sections, are very largely dependent upon the care and attention given by the

owner. In certain regions, however, it is difficult to succeed, whereas in others a complete fruit failure is comparatively rare. The one controlling factor in the Great Plains area, outside of those sections where water for irrigation is available, is the lack of moisture, yet after the trees have become well established it is not often that this causes more than temporary loss, such as a crop of fruit for a single season.

In some sections winds and hailstorms occasionally cause damage, but these losses are not more frequent with fruits than with the field crops. However, the trees sometimes suffer permanent damage from hailstones, even being killed in some cases.

The majority of the settlers on the Great Plains must depend upon their own plantations for a supply of fruit for home use. Most of those who do not have home-grown fruit are obliged to do without it. The chief interest, therefore, in the cultivation of fruit in this area centers about the home and the production of enough to meet the needs or desires of each family. In other words, fruit growing here is a home-making rather than a money-making enterprise.

The geographical position and extent of the Great Plains area are shown in Figure 1. Its western boundary, as indicated, is the 5,000-foot contour; its eastern boundary is arbitrarily placed at the ninety-eighth meridian.

SITES FOR FRUIT PLANTATIONS

Probably the greatest obstacle, either directly or indirectly, to the successful growing of fruit in the Great Plains area is lack of moisture in the soil. It follows, therefore, that the site for an orchard or small fruit garden should be selected with a view to securing the maximum supply of soil moisture. In many instances, particularly on the smaller ranches, the conditions are so nearly uniform that there is no choice in this respect. The convenience of the site with regard to the buildings will usually be the ruling factor in such cases.

But on many ranches there are sites that are more favorable for fruits than others on account of the soil-moisture factor; for instance, where a small stream or arroyo passes through the ranch it may furnish an additional supply of water. In some cases the topography is such that a reservoir can be made by building a small dam across the stream and diverting the water to the orchard. Not infrequently some of the larger streams that pass through this area have an underflow that extends some distance on either side. Where this condition prevails and the underflow is reached by their roots, the trees often make a remarkable growth.

Again, there are many instances where the lay of the land is such as to result in a large amount of run-off during heavy rains. If this run-off, which would otherwise be lost, can be collected in small contour ditches and distributed where fruits are planted, a considerable increase in the supply of moisture is secured. A coulee that opens away from the prevailing wind and traps quantities of snow is often an excellent place for an orchard. A shelter belt is almost essential in some places (fig. 21). Advantage should be taken of every factor which will increase or conserve the supply of moisture in the soil.

CLIMATIC FEATURES OF THE GREAT PLAINS

The climate of the Great Plains has been classified as semiarid. It may be better to say that it is variable. One season may have almost humid and another almost arid conditions. The mean annual precipitation is relatively low. Years of relatively high precipitation may be followed by years of relatively low precipitation. Other climatic factors usually correspond with the rainfall. In a year of relatively high rainfall there will be a lower rate of evaporation and higher humidity than in a year of low rainfall.

Another climatic factor of much importance in crop production on the Plains is the distribution of the rainfall. This is probably more important in crop production than the amount of annual rainfall. A relatively low rainfall, properly distributed, may produce a crop where a much higher rainfall, unfavorably distributed, may accompany a crop failure.

TABLE 1.—*Annual and seasonal precipitation and seasonal evaporation at 14 stations in the Great Plains area*[1]

Station	Altitude (feet)[2]	Precipitation (inches)[3]						Seasonal evaporation (inches)[3]		
		Annual			Seasonal					
		Minimum	Maximum	Average	Minimum	Maximum	Average	Minimum	Maximum	Average
Judith Basin	4,228	14.96	23.78	18.06	7.04	17.21	9.34	22.012	29.353	24.491
Huntley	3,000	11.92	11.92	11.92	5.92	6.02	5.79	23.754	24.214	23.984
Williston	1,875	10.28	18.99	14.84	4.75	14.49	9.66	20.422	26.877	24.216
Dickinson	2,543	11.93	21.22	16.69	6.85	16.28	9.79	20.673	25.745	23.919
Edgeley	1,468	11.94	21.95	16.71	7.85	14.98	10.11	18.663	24.893	21.806
Hettinger	2,253	12.72	15.68	14.20	8.92	12.47	10.36	21.539	28.239	24.639
Belle Fourche	2,950	6.64	17.73	13.11	4.08	9.78	6.90	26.472	33.750	28.794
Scottsbluff	3,950	13.77	18.51	16.14	2.53	8.52	4.69	23.804	29.381	26.081
North Platte	3,000	11.18	23.01	18.05	6.85	12.36	9.45	28.445	38.168	32.359
Akron	4,600	14.51	22.46	18.28	6.42	13.86	9.02	26.064	35.654	31.420
Hays	2,050	15.59	27.80	21.30	8.18	17.97	11.17	30.625	44.373	35.790
Garden City	2,909	11.82	23.58	18.54	2.79	14.43	8.65	34.325	43.510	38.185
Dalhart	4,000	13.69	16.35	15.11	5.09	9.85	8.01	35.459	41.748	38.968
Amarillo	3,676	10.69	27.80	18.28	6.17	11.38	9.13	33.804	42.076	36.724

[1] The period of time covered by the investigations made at the several stations ranged from two to eight years, depending upon the time when the different stations were established, the same period being covered by the data regarding precipitation and evaporation shown here.

[2] The altitude given is based in most cases on that of the nearest town.

[3] The records of annual precipitation for 1914 are not included. The records of seasonal precipitation and evaporation for 1914 are included for all stations, being figured from May 1 to Sept. 1. Evaporation measurements are made from a free water surface, in a tank sunk into the soil to almost its full depth. The water surface is kept about level with the surface of the ground

Table 1 gives the maximum, minimum, and average annual precipitation and the seasonal maximum, minimum, and average precipitation and evaporation of the Great Plains area. By seasonal is meant the period between the average time of seeding and the average time of harvest. * * *

Figure 2 shows the earliest and latest dates of the last killing frost in the spring, the earliest and latest dates of the first killing frost in the fall, and the average length of the frost-free period at each station. Each hatched horizontal bar represents the period between the average dates of the last killing frost in the spring and the first killing frost in the fall. The number of days in the average frost-free period for the station is shown in the figures above the bar. The solid-line curve at the left shows the earliest date at which the frost-free period has begun. The broken-line curve at the left represents the latest date at which the last killing frost of the spring has occurred. The solid-line curve at the right represents the earliest date and the broken-line curve at the right the latest date at which the first killing frost of the fall has occurred.

This diagram [fig. 2] shows clearly the increase in the length of the frost-free period from the north to the south. The shortest average period is 100 days, at Hettinger, and the longest 194 days, at Amarillo.[2]

[2] See Chilcott, E. C., Cole, J. S., and Burr, W. W., "Crop production in the Great Plains area: Relation of cultural methods to yields." U. S. Dept. Agr. Bul. 268, pp. 3–4, fig. 2. 1915. Out of print, but may be consulted in libraries.

In the Great Plains area the regional restrictions to fruit growing, so far as the natural conditions are concerned, are primarily factors of temperature and moisture.

In some sections of this area, especially the northern part, fruits for planting must be selected with a view to their hardiness and their ability to endure extremely low temperatures in winter. But throughout the Great Plains area as a whole unseasonable frosts during the blossoming period or at other critical stages of growth more often cause damage than extreme cold during the dormant period. However, the combination of relatively low winter temperatures, limited moisture supply, and drying winds that sometimes prevail is extremely trying on most fruit trees and may cause serious damage where any one or even two of these factors operating at the same time would not adversely affect the trees.

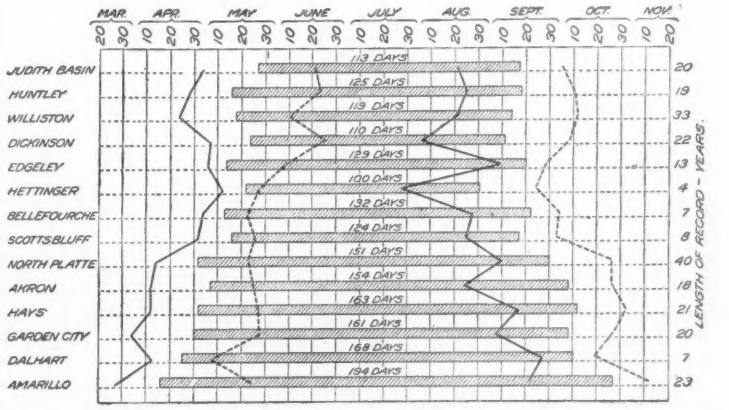

FIG 2.—Diagram showing the average frost-free periods and the earliest and the latest dates at which the last killing frost in the spring and the first killing frost in the fall has occurred at 14 stations in the Great Plains area

The general climatic features of this area are well indicated in the paragraphs above quoted. In that connection the statements are applied to the production of general agricultural crops, but they are none the less applicable to fruit growing.

Another climatic factor that occasionally does great damage is hail. Trees of considerable size are sometimes completely killed or so badly bruised or otherwise injured as to render them worthless. Hailstorms occur much more frequently in some parts of this area than in others. In sections where they are known to be severe, the planting of fruits is likely to prove disappointing.

Some sections of the Great Plains are further characterized by winds which blow almost continuously. While the wind may not be a prohibitive factor in the growing of fruit in any section it is a serious one where it blows much of the time. It not only results in the premature dropping of the fruit, but it becomes practically impossible to prevent the tops of the trees from growing very much to one side.

PREPARATION OF THE LAND FOR PLANTING

For fruits, land that has been in cultivation for one season or for a sufficient length of time for the sod to have become thoroughly rotted is very much to be preferred to newly broken land.

The planting of fruits in this area should be done as a rule in the spring, and in any special preparation that may be made the aim should be to handle the soil so that it will contain as much moisture as possible at the time the planting is done.

In seasons of fairly abundant precipitation, especially if there is considerable rainfall or fairly heavy snows during the winter, there may be enough moisture stored in the soil in the spring to insure the starting of the trees, even if a crop has been produced the previous season. But because of the wide seasonal variation in the amount of precipitation, frequently falling far below normal, and the importance of an abundant supply of soil moisture in the spring at planting time, it is generally advisable to summer-fallow during the season that precedes the planting.

In addition to summer fallowing, an adequate supply of soil moisture is still further insured if deep furrows are opened in the fall along the lines of the tree rows. These will serve to collect both the drifting snow and some of the run-off during heavy rains which might otherwise be lost.

One very successful fruit grower on a dry-land ranch even supplements the furrows by digging in the fall rather large holes where the trees are to stand. The run-off, as well as the snow caught in the furrows, will tend to settle in the holes and thus still further augment the amount of moisture in the soil in the immediate radius of the trees. In some cases, cross furrows or furrows made at an angle to the direction taken by the run-off and leading to the holes might also be useful.

Under ordinary climatic conditions this method of preparing the land should result in its being well supplied with moisture, and the trees should start into growth readily and make a good development of roots so far as the soil moisture is concerned.

NURSERY STOCK

In the central portion of the Great Plains area, as represented by the United States Dry-Land Field Station, Akron, Colo. (fig. 1), the most favorable period for planting is usually the last of April and early in May. It varies in other parts of the area from earlier in the southern section to somewhat later farther north. Normally, nursery stock is delivered in the spring rather than in the autumn. It is absolutely essential for success that it reach its destination in a perfectly dormant condition. Hence, it follows that while it may be satisfactory for those ordering stock for planting in the southern part of the area to secure it from northern sources, it is not well to obtain it from the south for planting in the northern sections, on account of the fact that the buds may start on stock from the south before the most favorable period for planting in the north has arrived.

On account of the arid or semiarid conditions of this region the period following the planting of the trees is very trying unless there

is a sufficient supply of moisture stored in the soil and available for their use. The moisture in the trees is being dried out constantly, and more rapidly than would be the case in a humid region. The roots of newly planted trees do not at first readily take up moisture from the soil, and if it is excessively dry the trees may die before they can start into growth. Because of these moisture factors it is of the greatest importance to procure only trees and other nursery stock which are most likely to start into growth readily and quickly when planted.

In many fruit-growing regions apple, pear, plum, and cherry trees are commonly planted when 2 years old; that is, after they have made two seasons' growth in the nursery from the bud or graft. However, in some commercial apple and cherry growing sections there is a strong sentiment in favor of 1-year-old trees for planting in preference to older ones. The younger trees have an advantage in that it is possible to form the tops at any desired height. The heads are already formed on 2-year-old trees when received. Not infrequently the trees have been headed too high to be desirable, and it is not always possible or practicable to plant such trees deep enough to overcome this objection. And, again, good, strong 1-year-old trees, as a rule, withstand transplanting fully as well as older trees; they are lighter to handle in shipping and in other ways are more desirable. This is true of other trees as well as of apples and cherries.

Inexperienced buyers of fruit trees not infrequently measure the value and grade of the trees delivered by their size; the larger the tree the better it is supposed to be. But experience has proved that thrifty, medium-sized trees are better for planting in the Great Plains area than larger ones, with a preference for good, strong 1-year-old trees. The larger 2-year-old trees as a rule do not withstand transplanting as well, nor are they as likely to live and make a good growth as the medium-sized ones of the same age.

On the other hand, a very radical distinction must be made between medium-sized or relatively small healthy trees and those which are small because they have been stunted by some adverse condition. Weak, stunted trees should be refused absolutely. They are likely to be expensive even as a gift.

Good root systems are also of special importance in satisfactorily starting trees planted under the conditions which normally prevail in this area. In sections where all the factors influencing growth are favorable, the difficulties incident to poor roots, if not too serious, may be overcome perhaps without permanently harmful results; but in the region under consideration well-developed and abundant root systems are especially important. If the roots of trees consist of only a very few large parts, new growth does not start as readily and as quickly as it does if the plants are well provided with a large number of small roots.

But here again caution is necessary. A large mass of very fine threadlike roots is due cause for suspicion. Such roots may indicate a disease known as hairy-root, a form of crown gall. Although there is a wide difference of opinion and experience concerning the seriousness of this trouble, it is by far the safer plan to discard trees so

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affected; the roots in any event are abnormal and if planted there is always the possibility that the trouble will develop to such an extent as to affect seriously the vigor and durability of the tree. All trees and vines showing crown gall or abnormal growths of any kind should be rejected.

The height of the tree is as important as its root system. Trees that have been headed from 1½ to 2½ feet high as a rule start into growth more readily and develop better than trees headed 3 to 3½ feet high. In a large majority of cases the high-headed trees, even when they live, make only a very small growth the first season and rarely develop well-formed, satisfactory tops as they increase in age.

HANDLING THE STOCK WHEN RECEIVED FROM THE NURSERY

It has already been stated that planting in the spring rather than in the fall is to be advised in this area. To insure the timely arrival of the stock from the nursery it is wise to order it shipped with a view to its arriving at its destination a little in advance of the actual date of planting. Otherwise, an unexpected delay in shipping or during transit may result in inconvenience or in the undue starting into growth of the stock before it is received.

To hold trees and other plants in good condition until planted, they should be unpacked immediately upon arrival and heeled in without delay in a well-drained spot. The heeling in is accomplished by digging a trench 12 or 15 inches deep, sloping on one side. The roots are placed in the trench, the trunks of the trees lying at right angles to it on the sloping side. The position is illustrated in Figure 3. In case the trees are tied in bundles when received they should be separated; otherwise, the roots can not be properly protected. Moist, finely pulverized soil should then be worked thoroughly in among the roots, completely filling all the spaces, and the roots finally covered several inches deep.

If it is necessary for any reason to have the trees heeled in for a long time before they are planted, it may be advisable to cover the tops, entirely or nearly so, with soil, to prevent the sap from being dried out to an undue extent. With the first advent of warm weather, however, the branches should be uncovered.

The soil that is placed over the roots and such other parts of the trees as may be covered should be packed very firmly. This is not only for the purpose of excluding as much air as possible, but to lessen the danger of mice finding a harbor among the trees, where they might cause injury by gnawing the bark.

Trees that are heeled in should be examined frequently, with especial reference to moisture conditions. While the soil about the roots should not be kept in a water-soaked condition, it should not be permitted, on the other hand, to become thoroughly dry. The sap in the trees would be likely to dry out and the bark shrivel if this should occur. Difficulties of this sort can be avoided easily by the judicious application of water.

Berry bushes and other small fruits are handled in essentially the same manner as trees, but the trenches in which the roots are placed are shallower than for tree fruits, to correspond with the size of the plants.

PLANTING THE TREES AND OTHER NURSERY STOCK

The most satisfactory time for planting fruit trees and bushes in eastern Colorado in the average season is the last of April or the first of May. The soil is usually in good workable condition at this time, and as a rule it is a period during which there is considerable precipitation. These conditions are favorable for growth, and if a tree or other plant reestablishes itself readily in its new place and growth begins promptly one of its most critical periods is past.

The best time for planting fruits in the other parts of the Great Plains area may vary somewhat from the dates for Colorado given above. Generally, it may be done earlier in the southern sections and later in the north. It should be done after the danger of hard

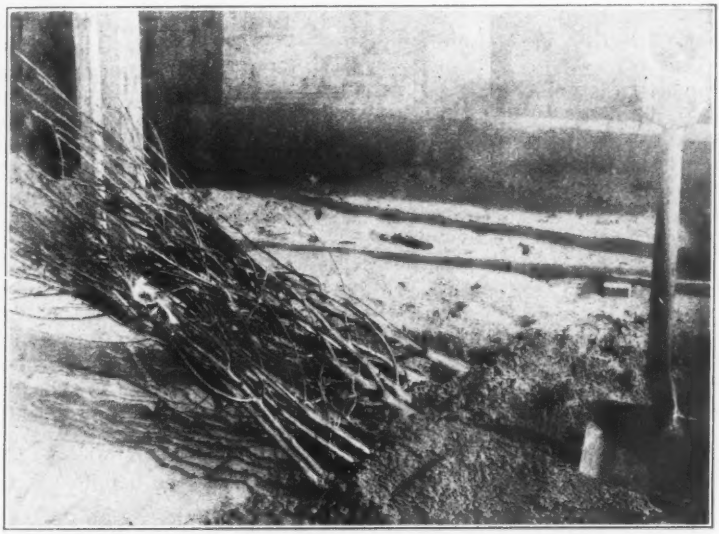

FIG. 3.—Peach trees heeled in. The position in which the trees are placed is to be noted

freezing temperatures is past and when the soil is in good condition for working; otherwise, the earlier the better, usually.

The method of planting fruit trees in this area does not differ in any essential from that commonly followed in other parts of the country. In handling the trees every possible precaution needs to be taken to prevent the roots from becoming dry when the trees are removed from place to place. The roots should not be exposed to the air more than is absolutely necessary. Covering with wet burlap is, perhaps, the most convenient means of giving protection, but wet chopped straw, damp moss, or other materials that can be moistened and covered over the roots may be made to serve the purpose; or the roots may be protected by puddling them. This consists merely in dipping the roots in a puddle of clay. The clay should be of such consistency that a thin layer of mud will adhere to the roots when they are dipped into it and at the same time per-

mit them to be moved about in it with perfect ease and freedom. Such a coating of mud will afford considerable protection against undue drying out from exposure to sun and wind. By observing this precaution at all times, including the period of exposure incident to planting the trees, there should be no loss due to dried-out roots.

The holes are made broad enough to receive the roots without bending them from their natural position and deep enough so that when filled even with the surrounding surface the trees will stand 2 or 3 inches deeper than they did in the nursery. Sometimes the holes are made in the fall, as previously described.

Before planting, the ends of all broken roots and roots otherwise injured should be removed with a smooth cut. As the trees are placed in position in the holes the soil is carefully worked around the roots and firmly packed by tramping. If the soil is moderately moist it will not be necessary as a rule to water the trees when planted; but if the soil is dry it may be well to pour a pail or two of water into the hole after it has been partially filled with soil, and then complete the filling after the water has soaked in. The subsequent use of water should be governed by conditions. If it continues dry after the trees are planted an occasional application of water sufficient to keep the soil in the vicinity of the roots well moistened may enable the trees to grow readily when otherwise they might fail entirely from lack of moisture.

When the trees are planted they should be headed back to the desired height. It is believed from experience and observations under Great Plains conditions that the main stem or trunk of the tree should not exceed 2 or 2½ feet in height, measuring from the surface of the ground after the tree is planted. In many cases the heads may well be formed even lower than this. Trees with low heads are not as likely to be injured by sun scald as those with high heads, nor are they as much affected by the wind. If the trees have been headed in the nursery, as is the case with stock 2 years old, it is often impossible to handle them so as to place the heads at the desired height. With 1-year-old trees this difficulty does not exist.

There is a wide difference of opinion and practice among fruit growers as to the details to be observed in shaping the permanent head of the tree, but the conditions attending tree growth in this area are such that it is believed an open head which develops from a few main branches is preferable to one so managed that it becomes dense and bushy.

To develop an open head, only four to six branches should be left when the tree is pruned at the time it is planted, or when it is formed later if 1-year-old trees have been used. These branches should be selected with a view to their position on the trunk. They should be arranged symmetrically and spirally about the trunk and should start from different levels, thus leaving some space vertically between the different limbs. If two limbs branch from the trunk at the same level there is much more danger that they will split down in later years under the weight of a large crop of fruit or during a heavy wind than where the formation is as here suggested.

The branches selected for the permanent top of a 2-year-old tree should be cut back considerably at the time the tree is planted. If the

tree has made a fairly vigorous growth in the nursery the preceding season, one-half or two-thirds of the length, as a rule, may be cut away. This will tend to make the branches strong and stocky rather than slender and "leggy," as when no cutting back is done.

This plan of forming the head also reduces the number of branches which the roots are required to supply with moisture during the first season's growth. It should be kept in mind that a considerable portion of the root system is lost in digging the tree from the nursery and that the branches need to be reduced proportionally.

The plan described is illustrated in Figure 4 and still further shown in Figures 5 to 10. Figure 4 shows a McIntosh apple tree in July of its second season's growth in the Akron fruit garden. It was headed low, the number of permanent branches was reduced to four or five, and from the very beginning the top has been kept open. The same plan of development may be seen in the other illustrations mentioned.

FIG. 4.—A McIntosh apple tree in July of its second season's growth, which has been pruned with a view to developing an open head. Akron, Colo.

The method followed in planting small fruits is essentially the same as that described for tree fruits. They are planted, as a rule, a little deeper than they were originally. They are cut back, if necessary, to make the tops correspond to the root system, and in other respects the directions given above are readily adapted to handling small-fruit plants.

Because the roots of small fruits are nearer the surface than those of tree fruits it may be necessary to give more attention to watering newly set plants until after they start into growth than is suggested for trees. This applies with special emphasis to strawberries.

PROPER DISTANCES FOR PLANTING

The distance between fruit trees is a matter of greater importance than is commonly realized. The space unoccupied at the time the small trees are planted seems out of proportion to their size, but the

requirements when the trees are mature must be anticipated. It should be remarked that the roots extend very much farther than the spread of the branches, contrary to a commonly expressed notion. At Cheyenne Wells, Colo., the roots of a 14-year-old apple tree were traced 26 feet in one direction from the tree and some 9 or 10 feet in the opposite direction, making a spread of at least 35 feet; in fact, the actual spread was several feet more than this, as it became impracticable to trace the roots in the very dry, hard soil to their ends.[2] The great number of roots that develop on apple trees under semi-arid conditions is suggested by Figure 11, and the expanse of the roots is shown in Figure 12. It was 26 feet from the stump to the

FIG. 5.—A Delicious apple tree after two seasons' growth as it appeared before its annual pruning. The foundation for the top consists of four or five main limbs

FIG. 6.—The Delicious apple tree shown in Figure 5 after being pruned. Both figures were reproduced from photographs taken at Akron, Colo., in November

end of the root held by the man shown on the left in the illustration (fig. 12).

It therefore appears that trees in their earlier life may suffer more from the crowding of the roots than from the crowding of their tops. The bearing which these facts have on the welfare of the trees is largely in relation to the moisture supply. If the trees are too close together their combined moisture requirements may exceed that furnished by normal precipitation.

[2] This study of the root systems was made in August, 1910, at the Dry-Land Substation of the Colorado Agricultural Experiment Station by J. E. Payne, then connected with that station, and one of the writers. For further details, see Payne, J. E., "Notes on a dry-land orchard," Colo. Agr. Exp. Sta. Bul. 173. 1910.

Too close planting is a common fault in many of the commercial fruit-growing districts in irrigated as well as in humid sections. Its results in semiarid sections where irrigation is not practiced are likely to be particularly serious.

Although fruit trees may not grow as large under the semiarid conditions of the Great Plains as in humid sections, it is not believed that this fact is sufficient to warrant close planting. On the other hand, the size attained here by trees is likely to be governed very largely by the amount of moisture available.

FIG. 7.—The same Delicious apple tree shown in Figures 5 and 6 as it appeared in July of the following season. The buds near the ends of the stubs in Figure 6 have developed into branches, thus making a good framework for the development in the future of a strong, well-branched tree. Akron, Colo.

In the light of the foregoing statements, the following distances each way for the planting of different fruits are suggested:

Apples, 30 to 35 feet.
Pears, 25 to 30 feet.
Peaches, 20 to 25 feet.
Plums, 20 to 25 feet.
Cherries, 20 to 25 feet.
Sand cherry-plum hybrids, 10 to 15 feet.
Currants, 5 to 6 feet.
Gooseberries, 5 to 6 feet.
Raspberries, 6 to 7 feet.
Blackberries, 6 to 7 feet.
Strawberries, usually in rows 3 or 3½ feet apart, with the plants 1½ to 2 feet apart in the row.

Many of these distances may seem excessive at first, but they allow none too much space when the demands of mature trees and other plants for moisture and plant food are taken into account.

TILLAGE

The tillage (or cultivation, as it is more commonly termed) of a fruit garden or orchard in this region should be very thorough. Its primary objects are to maintain the surface of the soil in a fine granular condition, so that it will readily absorb all of the rainfall, and to prevent the growth of weeds. A fine dust mulch does not take up the moisture as freely as a granular surface does.

The other objects of tillage will generally follow as a matter of course. Usually it should be continued fairly late in the season.

During one year seasonal cultivation in the dry-land ranch garden at Akron was discontinued early in August in order to avoid further stimulation of growth and to insure a thorough ripening of the wood before the advent of cold weather. However, no beneficial results followed that could be attributed to the cessation of cultivation as early as this; and, besides, it might prove a rather hazardous plan in some seasons. The growth of weeds following the cessation of cultivation so early in the season was sufficient to make a serious drain on the supply of soil moisture. The danger lies in the fact that the moisture in the soil might be reduced

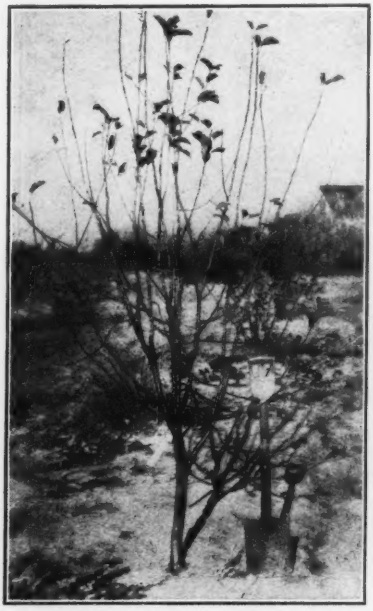

FIG. 8.—An Utter apple tree after its third season's growth as it appeared before its annual pruning. In previous years the pruning has been directed toward keeping the top open

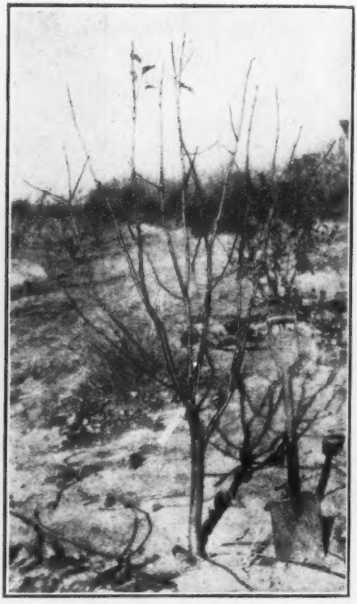

FIG. 9.—The Utter apple tree shown in Figure 8 after being pruned. Both illustrations (Figs. 8 and 9) were reproduced from photographs taken at Akron, Colo., in November

to such an extent that the trees would suffer during the winter or the following season in case there was little precipitation.

Tillage in the garden at the United States Dry-Land Field Station has been frequent enough to destroy weeds before they have made any considerable growth, to prevent the soil from blowing, and to insure against any run-off during heavy showers. To these ends the surface has been kept in a rough, granular condition. In accomplishing these objects, the soil moisture has been well conserved against evaporation from the surface. Tillage has usually been continued until the latter part of August, or late enough to prevent any considerable growth of weeds and to avoid all danger of their going to seed.

This practice with regard to tillage has given good results in the Akron garden. Moreover, in its general principles it has been followed by ranchers in other sections of this area in the successful growing of fruit. Slight modifications of this plan of tillage may be necessary under some soil and climatic conditions, but it is believed that it embodies the essential features, so far as this operation is concerned, in maintaining orchards and fruit gardens in this area, not only while they are young but after they reach maturity.

Clean tillage throughout the season during the early life of an orchard amounts practically to summer fallowing. During the first three or four years and before the roots have extended very far, the demands made by the trees upon the soil moisture are comparatively small. With normal precipitation the tendency obviously would be for the percentage of soil moisture in the spaces between the trees to increase rather than to decrease under this method of management. In this way, the greater demands of the trees for moisture as they reach larger size are anticipated in a measure, at least for a time.

FIG. 10.—The same Utter apple tree shown in Figures 8 and 9 as it appeared in July of the following year. Akron, Colo.

Cover crops and green-manure crops serve a most important purpose in maintaining the fertility of orchard soil in humid and irrigated sections, but in this area where the soil moisture is so largely the limiting factor their use rarely, if ever, can be advised. The growing of these crops usually would draw so heavily upon the moisture in the soil that they would be a menace rather than a benefit to the fruit. The humus furnished by such crops in sections where they can be grown must be supplied here by applying manure or vegetable matter in some other form.

For a similar reason the interplanting of crops between the rows of trees in young orchards, as is commonly done in commercial fruit-

growing sections, can not be recommended in this area. In the case of apple trees planted 30 or 35 feet apart, a row or two of corn or some vegetable possibly could be planted for the first two or three years midway between the rows of trees without irreparable harm to the latter, but the wisdom of even this limited competition with the trees would usually be doubtful.

The tools used in cultivating fruits may be a disk harrow, corn cultivator, or shovel cultivator, as conditions or convenience may dictate. While there are specially constructed orchard-tillage implements, the same tools used in the cultivation of general crops may be used advantageously in most cases.

FIG. 11.—Part of the root system of a 14-year-old Ben Davis apple tree. Colorado Experiment Station, Plains Substation, Cheyenne Wells, Colo., in August

PRUNING

There is probably no phase of fruit growing on the Great Plains which requires greater care and attention in order to obtain the best results than the operation of pruning. Although this is especially true of tree fruits it is also of importance with small fruits.

One of the commonest faults to be found with fruit trees on many ranches in the Great Plains area is the density of the tops. This fault, however, is not more characteristic of fruit growing in this area than it is in many other parts of the country. It is a natural consequence in the first place of planting trees without properly forming the heads at the time they are set out and of improper pruning or no pruning at all in after years. In fact, as will be illustrated later, it is often practically impossible to correct the faults incident to improper pruning at the time of planting by pruning when the trees are several years old.

If only a single idea were to be kept in mind in pruning a fruit tree throughout its life, that idea might well be to keep the top sufficiently open to admit air and sunshine freely. If this is accomplished, most of the other objects for which fruit trees should be pruned will also be realized.

The fear that the branches will be injured by exposure to the sun is frequently offered as a reason for allowing the tops to become very dense. It is true that where a large limb which has been shaded continually is suddenly exposed to the direct rays of the sun serious injury may result, but when a tree is grown from the beginning with an open head and is properly pruned there is little danger from this cause.

In further understanding the principles of pruning, the reader will be assisted by reference to the accompanying illustrations, most

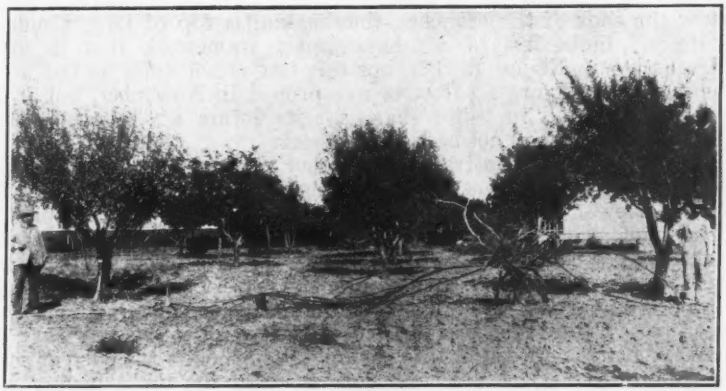

FIG. 12.—The same stump of a Ben Davis apple tree shown in Figure 11. The roots were traced a distance of 26 feet on the left and 9 or 10 feet on the right. The small extremities of the roots, amounting probably to several feet in length, still remained in the soil

of which are made from photographs taken in the Akron fruit garden.

Figure 4, previously referred to in connection with the planting of trees, shows also the pruning which was done following the first season's growth. The limbs were cut back to the points just below the level of the upper part of the spade handle, where the secondary branching may be seen. Branches which may have crossed each other and other superfluous growth were also cut out. While the top is open, it will be observed that the main limbs are well protected by leaves that developed from short spurs or buds. In a very dense top there would be but little development of leaf-bearing spurs along these limbs. The photograph reproduced here was taken in July. A good strong current season's growth is evident. This growth would normally be headed back during the following dormant season, and such thinning out as might seem necessary to maintain the top in a well-opened condition would be done at the same time.

Figure 5 shows a Delicious apple tree that was planted in the spring. The top was lightly pruned in July of the same year, the superfluous branches being removed. This figure shows the tree as it looked in November of the following year. The current season's growth of some of the branches was 2 to 3 feet, with practically no side branches. Figure 6 shows the same tree after it had been pruned. The results of this heavy heading back in November become apparent by reference to Figure 7, which shows the same tree the next July.

The strongest growth has taken place from buds near the ends of the stubs of branches shown in Figure 6. This is resulting in a well-proportioned stocky tree, yet one which can be kept well opened to the air and sunshine with a minimum amount of pruning. Had this tree been left, as shown in Figure 5, without heading back, the branching the next season probably would have occurred from buds near the ends of the branches, thus making a top of long, slender, "leggy" limbs instead of the compact framework that is seen developing in Figure 7. Perhaps this tree is not quite as tall now as it was in Figure 5 before it was pruned in November, but it is more stocky and in better shape for its future development than it would be if it had not been headed back.

Figures 8 and 9 illustrate still further the idea expressed in Figures 4 to 7 with reference to developing trees with stocky open tops. These show an Utter apple tree that was planted in the spring. The photographs from which these illustrations were made were taken in November two years later, before and after pruning. The tree had then completed three seasons' growth. From the beginning, it has been handled with a view to keeping the top open. As may be seen from Figure 8, in comparison with Figure 9, it was necessary to remove but little wood at this pruning, even though the current season's growth had been very strong, many of the limbs having increased 2 feet or more in length. The tree was started with a framework of four or five branches. With these as a foundation and with a small amount of corrective pruning each year the tree remains under easy control.

In contrast with the average apple tree to be found in this area, the one shown in Figure 9, as it here appears, may seem to many to be entirely too open. During the next season, however, the development of leaves and many small side branches, which may be expected eventually to form fruit spurs, causes the tree to present a very different appearance, as shown in Figure 10. As seen here it is in its fourth season's growth. It will not be headed back very much in the pruning which it receives in the future. Heavy heading back tends to stimulate additional wood growth. This tree has now been well shaped. The limbs that form the framework of the top, as well as the trunk, are stocky and strong. It is in good condition to begin to bear fruit. There is, therefore, no further need of pruning to encourage additional wood growth, but more or less thinning out of the top probably will be necessary each year. Slight heading in at times may be advantageous, but the foundation work, so far as pruning is concerned, has now been completed.

The keeping of the top well opened during the first few years is favorable for the development of spurs and short branches along the

limbs, thus tending to the production of a large bearing surface. It is on such growth that many fruit buds subsequently develop. This so distributes the fruit on the main limbs that there is the least possible danger of their breaking from its weight.

It should be stated, however, that there is much yet to be learned about the effect of heading back the annual growth year after year. If trees with strong stocky limbs are to be developed, rather heavy heading in for several years after planting seems as a rule to be necessary. On the other hand there is considerable evidence that if this practice is carried too far it very materially retards the time of bearing. Moreover, in this respect, it seems probable that trees of different varieties should be handled differently. Some varieties naturally make a strong stocky growth and do not branch excessively, while others develop long, slender branches. Obviously these two types of trees should be treated differently with respect to pruning.

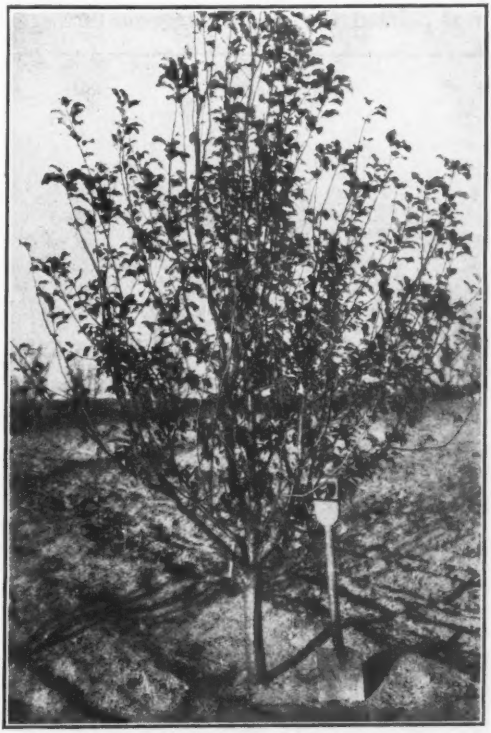

FIG. 13.—A Wealthy apple tree planted in the spring, which received no further pruning until after its third season's growth. Because of these years of no pruning it was not possible in later years to bring the top to a desirable form. Akron, Colo., November

It is, of course, desirable that a tree should come into fruiting as early as possible after it is planted, but the gain of a year or two in earliness of bearing is of small importance compared with the development of a type of tree which in later years will best meet the ends for which it is grown. It is the nice balance between earliness of bearing and other characteristics and the development of a tree which in the long run shall be best suited to fulfill the ends in view that constitutes the real problem in pruning during the early life of an orchard.

In rather strong contrast to the trees shown in Figures 4 to 10 are those in Figures 13 to 17. The latter illustrate apple trees that were planted in the spring. The photographs used in making

these illustrations were taken in November after the trees had completed their seventh season's growth. Because these trees are considerably older than those shown in Figures 4 to 10, the illustrations in the two groups are obviously not entirely comparable. Yet they show certain contrasts that are of fundamental importance in pruning fruit trees at the time of planting and during the first three or four years thereafter.

In contrast to Figures 4 to 10, Figures 13 to 17 show apple trees that were not trimmed with any particular ideal in view when they were planted, and they received no further pruning until after they had completed their third season's growth. After that time they were pruned each year. To the casual observer the objectionable features of these trees may not be conspicuous, but they become very real to one who wishes to prune them in a rational manner.

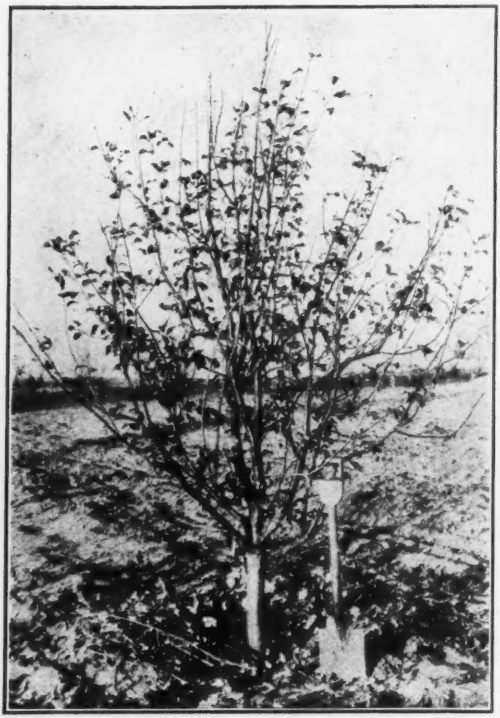

FIG. 14.—The Wealthy apple tree shown in Figure 13 after being pruned. Akron, Colo., November

Figures 13 and 14 show a Wealthy apple tree and Figures 15 and 16 a Patten tree in November, before and after pruning. Figure 17 is a Northwestern Greening apple tree not yet pruned. It will be seen by reference to the figures showing the trees before pruning that the tops are not extremely dense, as at the time the photographs were taken a good deal of the foliage had dropped. When the pruning was begun after three years of unrestricted growth, the tops of these trees were veritable heaps of brush. The pruning after the third year of growth was directed primarily toward the gradual removal of superfluous wood. However, because of the fact that the trees were not well formed at the time they were planted and during the first year or two thereafter, the pruning in subsequent years has failed and must continue to fail to reduce the work to the simple systematic operation that it is in the case of trees that are well pruned from the beginning. Most of the branches in these three trees (figs. 13, 15, and 17) are relatively long

and slender because they radiate so largely from a common axis or nearly from a common center. To keep the tops suitably pruned is difficult. If one of the larger limbs with its component branches is removed to open the top, the result is an unsymmetrical head; one side is made considerably lighter than the other.

The alternative in maintaining the tops sufficiently open for the free access of sunshine and air is to cut away a considerable number of the smaller branches. This tends toward the development of long slender unbranched limbs, with the bearing surface a little later in the life of the trees occurring only near the extremities.

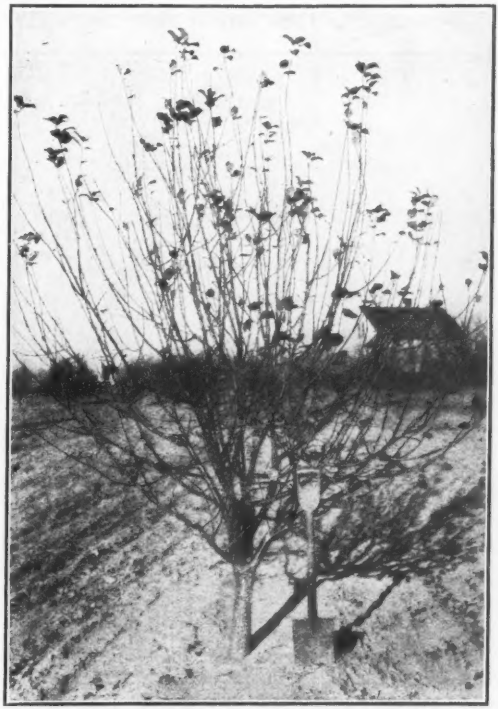

FIG. 15.—A Patten apple tree planted in the spring, which has received treatment similar to that of the Wealthy apple tree shown in Figure 13. Akron, Colo., November

The point in question is especially evident in Figure 17, where the tendency to make long slender growth is very conspicuous, in spite of the effort made during three or four years to put the tree into the best shape that its condition permitted.

A study of the illustrations here used emphasizes the fact, which all fruit growers recognize, that the natural habit of growth of different varieties must be considered in intelligent pruning. The upright habit of the Wealthy tree (figs. 13 and 14) and the roundish form of head shown by the Patten (figs. 15 and 16) and the Northwestern Greening trees (fig. 17) make the problem of pruning these two types quite different in each case, even though the principles involved are the same. The Utter tree in Figure 8 shows still another type of growth in that, even if left entirely unpruned, the top would not be likely to become as dense as that of the other varieties illustrated, because it does not branch so profusely. It is therefore less trouble to keep it well pruned, though the principles are the same as in pruning trees of the more profusely branching type.

The manner of pruning other fruit trees does not differ in principle from that followed with apple trees. Ordinarily the tops of

plum and cherry trees are not kept quite as open as apples, principally because of the greater natural tendency to form fruit spurs along the branches; but if due attention is not given to the proper forming of the tops when planted and to wise pruning subsequently, the same troubles as those detailed for apples are sure to follow. This fact is made evident by Figure 18, showing a native plum tree six years after being planted, which formed a head so dense that it was only with considerable difficulty that the fruit on the interior of the tree could be picked. Figure 19 is a Desoto plum tree a year younger. This variety does not make naturally as dense a growth as does the one in Figure 18; besides, it was planted one year later, so that it began to receive systematic pruning that much earlier in its life. These plum trees were headed back to some extent during the three or four years before they were photographed, but they will not be likely to require very much more heading back.

FIG. 16.—The Patten apple tree shown in Figure 15 after being pruned. Akron, Colo., November

The Early Richmond cherry tree in Figure 20, the same age as the Desoto plum, has responded fairly well to the corrective pruning that it received after it was 3 years old.

Another problem in pruning is suggested by the tree shown in Figure 21. In some parts of the Great Plains area rather strong winds blow much of the time. The influence of such winds can be more or less checked as a rule by growing a well-arranged system of shelter belts that extend across the path of the prevailing winds. A little can be accomplished also by pruning. The branches should be kept well headed in. This heading in may need to be done during the growing season if a long slender growth is being developed and it is being continuously forced far from its normal position. The top, if kept well opened, will offer less resistance to the wind than where it is allowed to become dense. Besides, if the tops are not too dense the branches will probably be less impeded in resuming their normal positions when the wind is

not blowing. However, a complete counteracting of the influence of strong prevailing winds is hardly to be expected except as the force of the winds is broken by shelter belts of some kind.

Great emphasis has been placed on pruning with a view to keeping the tops open. There are other reasons why systematic annual pruning should be done. Without regard to the order of relative importance, the more evident reasons may be enumerated as follows:

(1) Every branch is reaching out for sunlight. If the top is sufficiently open so that every leaf receives its full complement of sunshine there is less competition among the different branches than where the top is very dense.

(2) With the decreased struggle for existence among the branches, the crowding of the weaker ones and the resulting dead wood in the top of the tree are largely eliminated.

(3) The development of fruit-bearing spurs well within the center of the tree is encouraged because they receive sunlight, and sunlight in full measure is essential to healthy, vigorous growth.

(4) When a tree reaches bearing age it can be sprayed thoroughly, and it is evident that spraying will be necessary in this area if good fruit is to be grown. Besides, the fruit can be picked with reasonable ease and comfort. But not so if the picker must crawl through a brush pile to reach it.

(5) The above reasons are common to all fruit-growing regions. Another is of special significance on the Great Plains because of the limited rainfall. The conservation of the moisture in the soil is of the greatest importance. Great quantities of moisture are taken up by a tree and given off through the foliage. In general, the greater the amount of foliage the more rapidly is moisture given off. By proper pruning and thereby the holding of the top to a form or condition as to the number of branches and the amount of foliage which are most consistent with the objects for which the tree is desired, the less will be the loss of moisture from the soil through the foliage. Hence, it follows that wise pruning helps to conserve soil moisture.

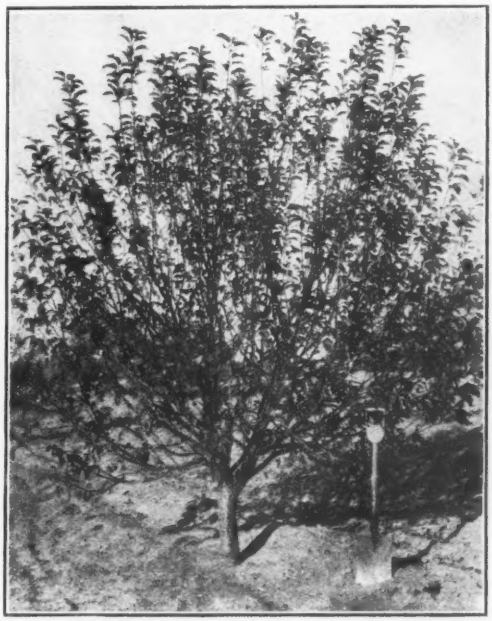

FIG. 17.—A Northwestern Greening apple tree planted in the spring, which has received treatment similar to that of the Wealthy apple tree shown in Figure 13. This is the largest apple tree in the garden. Akron, Colo., November

IRRIGATION

Although fruit growing on the average ranch in the Great Plains area must be largely under dry-farming methods, a relatively small quantity of water for irrigation may sometimes save fruit trees,

and especially strawberries and other small-fruit plants, during a particularly dry period.

Wells of large capacity and windmills are to be found on many ranches and often furnish an adequate supply of water for use in tiding fruits over a crisis of drought. On other ranches a supply of water for emergency use is sometimes stored in earth reservoirs, as suggested in Figure 22.

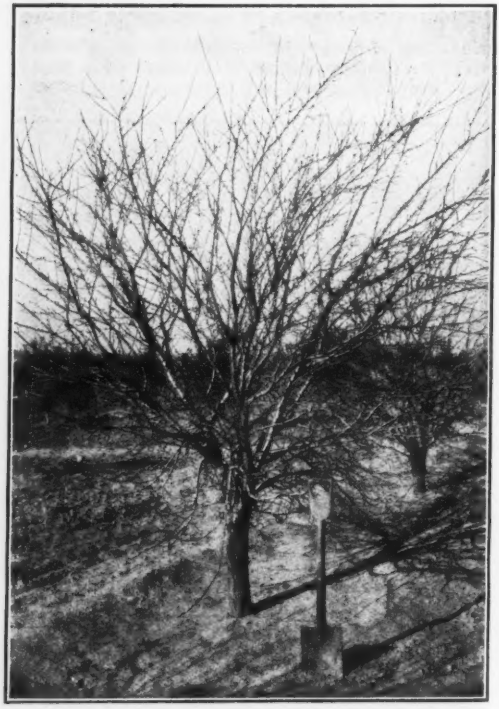

FIG. 18.—A plum tree of unknown identity planted in the spring, which is the largest tree of any kind in the garden, though during the growing season six years after planting the apple tree shown in Figure 17 nearly overtook it. It has received treatment similar to that of the Wealthy apple tree shown in Figure 13, but it is in better shape for a plum than the Wealthy is for an apple. Akron, Colo., November

Such a reservoir is made by excavating the earth and mounding it up somewhat about the edge or rim. The inside is then puddled with clay or in some other way made sufficiently impervious to water to prevent seepage. Obviously, it should be located if possible on a slightly elevated site. It may be filled from the ranch well when the water is not required for other purposes, and the water may be siphoned out when wanted for irrigation.

ORCHARD PESTS

The orchard pests in the Great Plains area are not known to be essentially different from those in other regions except as they are influenced by regional, primarily climatic, conditions.

On account of the comparative dryness of the atmosphere, fungous diseases are not as prevalent as in the humid regions, where conditions are more favorable for their development.

Insects, such as the codling moth and currant worm, may be expected to occur. It may be assumed that the methods of control that are effective in other regions will be equally effective in this area.

Rabbits are likely to injure young trees during the winter by gnawing the bark, and in some sections pocket gophers and prairie dogs may be troublesome. Information regarding the control of

these pests can be obtained by addressing the Department of Agriculture.

Sun scald sometimes occurs during the winter on the south or southwest side of the trunks, especially in the case of high-headed trees. Injuries of this kind can be prevented by shading the trunks in some way during the winter. Binding laths, narrow strips of board, or cornstalks about the trunks, or even wrapping them with newspapers, will furnish all the protection needed. The material used should be removed in the spring.

HAIL INJURY

The trees in the Akron fruit garden were once seriously injured by a hailstorm. The results may be of interest in connection with the handling of trees in other parts of this area which may be injured by hail. The oldest trees in the garden were completing their third season's growth when the storm occurred. The bark on the north side of the trunks and larger limbs of many of the trees was badly bruised, and in some instances practically torn from the trees. Nearly all varieties of apples and cherries sustained substantially the same degree of injury. There were several varieties of apples, however, that appeared as if by chance to escape in a slight degree, but it is hardly to be assumed that this was due to any greater resistance of these particular sorts to the hail. Most of the plum trees passed through this storm with relatively less injury than that received by the apple, pear, and cherry trees. The tops of the peach trees were practically killed.

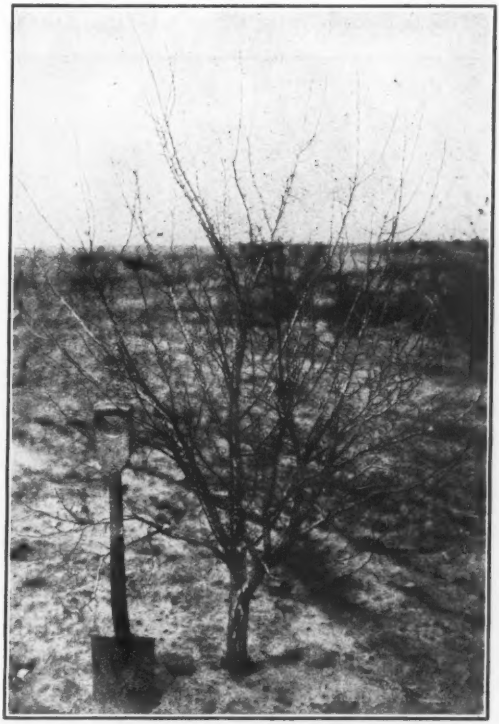

FIG. 19.—A Desoto plum tree planted in the spring which has received treatment similar to the other trees, but as its tendency to branch is less pronounced the top never became as dense as some of the other sorts. Akron, Colo., November

During the two years following this injury the tops of a good many of the apple trees died, and to some extent those of other kinds also. The seriousness of the wounds on the trunks became very evi-

dent. In many instances where the tops were injured beyond recovery, good strong sprouts developed from some point along the trunks. The one best suited for renewing the top was selected and the original top cut away.

The results which followed such serious hail injury have made it clear that the wiser course as a rule is to dig up and discard trees that show severe damage, especially where they have been planted only two or three years. If they have reached bearing age, or nearly so, it may be worth while to do everything possible to aid the trees in outgrowing the injuries.

The hailstorm referred to was the only one that caused injury of any consequence in this garden during an 8-year period.

FIG. 20.—An Early Richmond cherry tree planted in the spring, an example of a tree that did not receive proper pruning and shaping of the top the first two years, but which responded fairly well to corrective pruning during the next three or four years. Akron, Colo., July

FRUIT VARIETIES SUGGESTED FOR PLANTING

Although the cultural methods used in fruit growing in this area have much to do with the measure of success that is attained, they are not more important than the selection of varieties that are adapted to the conditions. In fact, the choosing of the best varieties, especially of the tree fruits for planting in the different sections of the area is really more of a problem than to determine what methods of culture to adopt. This is true in a measure with regard to every region in which fruits are grown. But where the conditions, as in this area, are especially trying and present at best but a rather narrow margin between possible success and prohibitive limits, the problem of varieties becomes especially acute.

As mentioned in the discussion of the climatic conditions, the limited moisture, relatively low temperatures, and, in some parts of the area, a good deal of wind which increases evaporation make a combination of climatic influences that is very trying to fruit trees.

Not all varieties will do equally well throughout the Great Plains. In the southern part of the area the winter temperatures are much milder than they are in the north, but the wind is a more serious factor in the south than in the north. The very low winter temperatures reached in the north make it possible to grow only the fruits that have a high degree of resistance to cold.

Although very much yet remains to be determined with reference to the adaptability of varieties to the Great Plains area, it is believed that the mention of a number of different fruits which have been planted more or less may be suggestive and of some help to those who are without experience in choosing varieties to plant in this part of the country.

APPLES

Southern section.—A few of the varieties of apples that may well be considered for the southern part of this area are the Yellow Transparent, Red June, San Jacinto, Maiden Blush, Gravenstein, Wealthy, Grimes Golden, Jonathan, Kinnard, Northwestern Greening, Texas Red, Winesap, Missouri Pippin, Arkansas Black, Ralls, and Limbertwig; for crab apples, the Florence, Hyslop, and Dartt. These varieties, named approximately in the order in which they mature, represent a long sequence of ripening, from the early to the long-keeping sorts.

FIG. 21.—A Northwestern Greening apple tree planted in the spring at the Amarillo Cereal Field Station, Amarillo, Tex., as it appeared in July four years later. The prevailing winds have blown so incessantly as permanently to force the branches to grow largely in one direction, thus making an unsymmetrical top

Central section.—Most of the varieties that succeed best in the southern part of the area could doubtless be planted in the central section. However, the behavior of the fruits in the garden at the Akron Field Station may be used to further the information concerning varieties in this part of the area, at least so far as the growth of the trees is concerned. Reference to the various illustrations in this bulletin showing apple trees in this garden will be of assistance in this connection.

Among the apple trees in the garden that have made a good growth are the following varieties: Yellow Transparent, Oldenburg, Wealthy, Northwestern Greening, Patten, McIntosh, Jonathan, Longfield, Grimes Golden, Utter, Okabena, and several others; also the Hyslop, Virginia, and Florence crabs. Some of the newer apple varieties considered promising are: Anoka, Haralson, and Erickson, also the Dolgo crab.

These varieties appear to be sufficiently hardy to withstand the normal conditions in this region, but thus far they have been disappointing in fruit production. Though old enough to bear considerable fruit as compared with other sections, they have produced very little here.

A number of dwarf apple trees were planted during the first year or two following the establishment of the garden. These include the Yellow Transparent, Oldenburg, Gravenstein, Wealthy, Bismarck, McIntosh, Esopus Spitzenburg, and Northern Spy. Thus far these trees have done well, and their behavior is such as to make them seem rather promising. Dwarf apples can not be recommended for planting, however, until after they have more definitely demonstrated their value.

FIG. 22.—An earth "tank," or reservoir, for irrigating small gardens and fruit plantations

Northern section.—Naturally the varieties that can be planted in this part of the area must be restricted to the hardier sorts on account of the extremely low winter temperatures. These include the Oldenburg, Wealthy, Hibernal, McMahon, Northwestern Greening, Patten, Malinda, the Hyslop, Virginia, and Florence crabs, and possibly some others named in the Akron Field Station list for planting where the conditions are not too extreme; also the newer varieties suggested under the "central section" for trial. There are some localities in this section, however, where even the hardiest sorts would be of doubtful value.

PEARS

There are hardly enough pears now growing in this area to show the range of their possibilities, unless their comparative absence is to be interpreted as signifying that they are not well adapted to these conditions. The Kieffer, Duchess d'Angouleme (*Duchess*),

Bartlett, and possibly one or two other sorts are occasionally grown in the southern part of the area. A variety supposed to be the Warner has grown well at the Akron Field Station, but has produced only lightly. The Flemish Beauty is one of the hardiest sorts and sometimes succeeds farther north than most other varieties. Except in sections with more severe weather, the Sudduth, Tait, and Mendel are suggested for trial.

PEACHES

Peach growing in this area is largely confined to the southern section, where a considerable number of varieties are grown to a limited extent. These include the Alexander, Sneed, Triumph, Arp, Carman, Mamie Ross, Chinese Cling, Elberta, Heath Cling, General Lee, Lemon Cling, and others.

At the Akron Field Station peach trees, including a number of the hardier sorts, were killed to the ground, or nearly so, every winter.

PLUMS

Plums, particularly the native sorts, are among the most dependable of all the tree fruits on the Great Plains. They have been planted quite widely throughout most of this area, and there is a fairly large number of varieties from which to choose. Of these the following are named, especially for the southern sections: America, Desoto, Golden (*Gold* of Stark Bros.) Kroh (*Poole's Pride*), Pottawattamie, Six Weeks, Surprise, Wild Goose, Wolf, and Wyant.

Among the more promising varieties at the Akron Field Station are the following: Brittlewood, Emerald (*Burwood*), Cheney, Desoto, Surprise, Terry, Wolf, and Wyant. The identity of the plum shown in Figure 18 is unknown, but it is one of the most promising sorts in the Akron garden. It resembles the Brittlewood somewhat and may prove to be of that variety. Most of these varieties have been planted widely throughout the Great Plains area. Several varieties of European plums, including the Lombard, Arctic, Shropshire (Damson), and others, have also been planted at this station. None can be considered promising. The trees make only small growth as a rule, and do not satisfactorily withstand winter conditions.

In parts of the northern section the following varieties are grown more or less: Cheney, Desoto, Forest Garden, Surprise, Waneta, Wolf, and Wyant. Some comparatively new sorts that appear to merit testing are: Elliot, Red Wing, Tonka, and Underwood.

The native plum trees in the fruit garden at the Akron Field Station have not been very long lived as a rule. In fact, in nature where they occur in thickets, the perpetuation of the thickets is usually dependent largely on the growth of sprouts or seedling trees. The trees in the center, and others as they attain age, are likely to weaken and die. Therefore the grower should not be discouraged if he finds it necessary to replant plum trees every few years. It would probably be wise to make new plantings occasionally in anticipation of the loss of older trees through natural causes.

PLUM HYBRIDS

Among plum hybrids the Compass cherry, a hybrid between the sand cherry and the Miner plum, has been widely planted in this area. It is proving to be of distinct value. Trees planted at the Akron Field Station began bearing two years later and have produced fairly regularly. Though not of high quality, the fruit is very acceptable. The tree comes into bearing early and seems to be perfectly hardy at Akron. Figure 24 shows a Compass tree as it appeared in November four years after being planted. The tree makes a very open growth; practically no thinning out of branches has been done in the tree shown here.

A number of other sand cherry-plum hybrids and other plum hybrids have been planted. In general they are desirable for the Great Plains area, being hardy and seemingly well adapted to the conditions under which many other fruits fail. The Opata, Sapa,

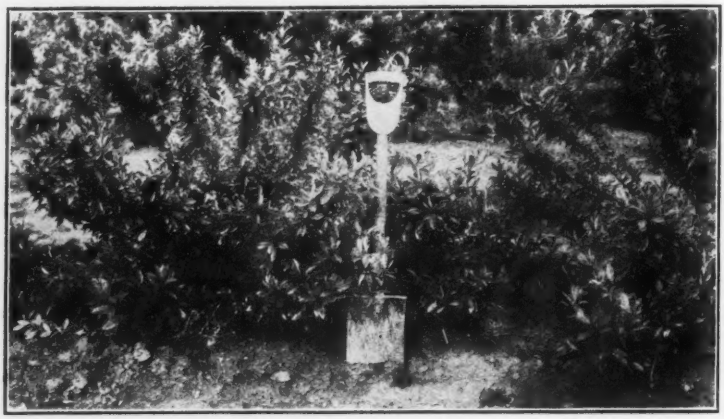

FIG. 23.—Sand cherries planted in the spring, fruiting heavily two years later. Akron, Colo., July

Sansoto, Oka, Tom Thumb, Hanska, Waneta, and Radisson are considered the better known or more promising hybrid varieties.

CHERRIES

Of the tree fruits, sour cherries are perhaps of equal value with native plums for this area. The number of varieties commonly grown is small, the Early Richmond, Montmorency, and English Morello comprising nearly all the trees that have been planted; in fact, there are probably to be found many times more trees of a single variety—the Montmorency—than all the others combined. These varieties are successful generally in the central and southern sections, as well as in some parts of the northern section, but in the latter there are large regions where the conditions practically preclude the growing of cherries. The Zumbra, a recently introduced variety, is promising for some parts of the northern Great Plains. It is a supposed compound hybrid of a pin cherry, a sweet variety, and the sand cherry.

A 6-year-old Early Richmond cherry tree at the Akron Field Station is shown in Figure 20. Several trees of the Black Tartarian and other sweet cherries have also been planted at this station, but they have either died or are in an unsatisfactory condition. It is not believed that sweet cherries are likely to withstand the conditions anywhere in this area.

Sand cherries also do well in many parts of the Great Plains area. The ones shown in Figure 23 fruited two years after being planted. The fruit is of value primarily for making jelly or preserves rather than for use in the fresh state. But as the sand cherry is native to the Great Plains, doubtless selections could be made which would bear fruit of fairly good edible quality.

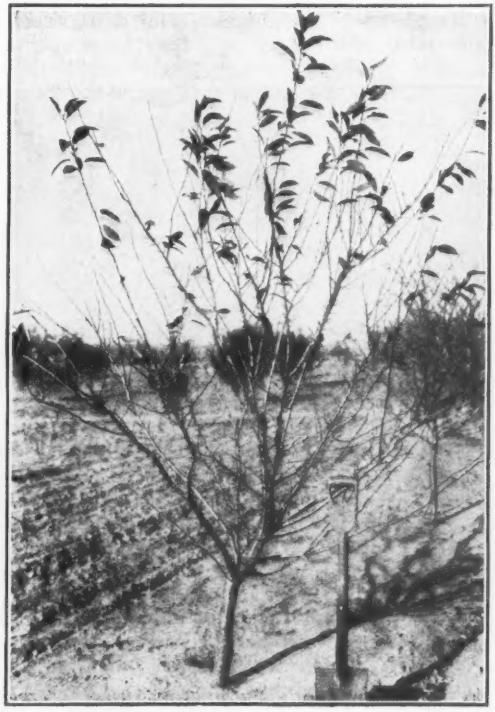

FIG. 24.—A Compass cherry 3 years old. The open spreading habit of growth is to be noted. Akron, Colo., November

CURRANTS

Currants appear to be one of the most satisfactory small fruits for the Great Plains. Most varieties do about equally well and are generally hardy. The London Market is perhaps grown in larger quantities than any other sort, but the Cherry, Victoria, Red Dutch and North Star, for red sorts, and the White Grape, for a white variety, have done well at the Akron Field Station. The Red Lake (*Minn. No. 24*) has been rather outstanding in yield and size of berry at the Cheyenne (Wyo.) Horticultural Field Station; the Diploma has also yielded well there.

The plants as a rule are a little slow the first year in getting started, but when well established they make a good growth if properly pruned. Figure 25 shows some currant bushes about 4 years old which are quite typical in growth of all the varieties at the Akron Field Station.

GOOSEBERRIES

In general, what has been said about currants is true also of gooseberries. They are quite dependable wherever currants are succeeding.

Like currants, the plants are a little slow in getting established and do not often make a very strong growth the first season. After they are once well established, they appear to be hardy. To keep them vigorous, however, the sprouts that habitually grow from the ground in rather large numbers should be kept well thinned out.

Probably the Downing, Houghton, and Poorman can be planted generally in this area with as much assurance of satisfaction as any other varieties. The Columbus has yielded especially well at the Cheyenne (Wyo.) Horticultural Field Station.

RASPBERRIES, BLACKBERRIES, AND DEWBERRIES

Raspberries, blackberries, and dewberries have not proved very successful in this area, and they have not been planted as a rule in the ranch fruit gardens. Generally speaking, they do not withstand dry weather well. Even in the humid sections heavy losses sometimes occur as a result of drought.

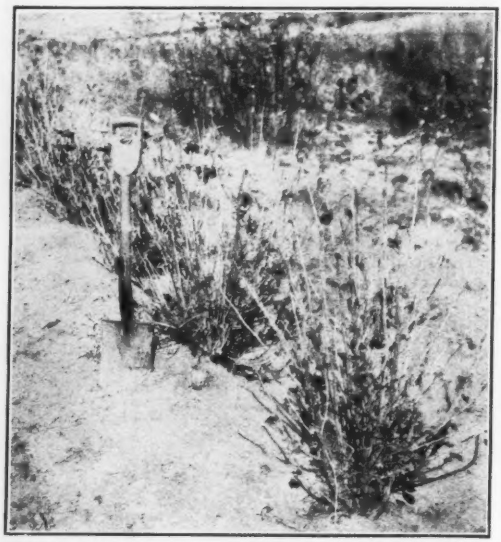

FIG. 25.—Currant bushes about 4 years old, showing typical growth, Akron, Colo., November

In many instances in this area the plants are slow in starting growth after being set out, though when once established the roots are quite persistent. The canes, however, are very apt to kill to the ground dur the winter.

Of the varieties observed in this area there seems to be but little preference, as there has been no important difference in their behavior. Of the raspberries, the Cuthbert, Loudon, King, and Sunbeam, for red sorts, and the Cumberland, Kansas, and Winfield, for black varieties, have been planted at the Akron Field Station. They have all borne a little fruit; possibly the Sunbeam has done fully as well as any other red variety; the Cumberland may be preferred among the black sorts. The canes of all varieties have winter-killed so badly that there is little choice for planting. No winter protection, however, has been given them. The Latham is suggested for trial and the Chief is promising; both are red raspberries.

Blackberries at the Akron Field Station have behaved in essentially the same manner as the raspberries. They are rather slow to start into growth after planting. The canes have been killed back

to the ground, or nearly so, every winter, and practically no fruit has been produced. The Himalaya, a variety the canes of which are perennial and normally do not die after producing a crop of fruit, as do the ordinary varieties, has made a fairly strong growth each year. However, it is not hardy enough to withstand the winters, though it does not usually kill back as far as do the other sorts. It has produced a very small quantity of fruit, which ripens over a long period, and only a few fruits are ever ripe at the same time, even on 10 or 12 large plants. The berries are small and imperfect, merest nubbins, and the proportion of seed to pulp is so large as to make the fruit almost inedible. Besides the Himalaya, the Snyder, Mersereau, and Rathbun varieties have been planted, none of which seem to be promising for this area.

Only one variety of dewberry, the Lucretia, has been planted. This bore a little fruit one year, but in general its behavior has been the same as that of the raspberries and blackberries.

Evidence is accumulating that the cane fruits, especially the raspberry, can be protected quite effectively during the winter by bending the canes to the ground along the row and covering them with 3 or 4 inches of soil. This may insure a crop in many cases, where failure would result without winter protection.

STRAWBERRIES

Success with strawberries in this area seems to be more largely a matter of the plants becoming well established and having an adequate moisture supply during certain periods than in the planting of any particular variety; in fact, the establishment of the plants is usually dependent upon a suitable amount of moisture in the soil. The roots are so near the top of the ground, at least until after growth has been well renewed, that they are very susceptible to the surface conditions of the soil. The roots of strawberries may dry out completely before a new growth starts, where other kinds of plants with their roots deeper in the soil would not be seriously affected. Hence, if newly set plants can be watered as needed until they are well reestablished after transplanting, the chief danger of failure in the beginning is eliminated. Unless this can be done, the plants will die in many cases before a new growth starts.

It is also important that water be available for use during the development of the fruit. At this period the strawberry requires a relatively large quantity of water. If it is lacking, the fruit will be small and much of it may fail to develop.

By mulching with straw during the winter to prevent repeated thawing and freezing as well as to protect the plants from extreme temperatures, strawberries can probably be grown almost anywhere in the Great Plains, provided water can be applied during the critical periods mentioned.

While irrigation might be quite advantageous at times in the growing of other fruits, it may often be practicable to water a small strawberry bed that can be located near the dwelling house, when it would be out of the question to water a fruit garden more or less distant from the buildings.

The Dunlap and Howard 17, with winter protection, are suggested for the northern section; these same varieties, together with the Beaver and the Rockhill (everbearing), for the central section; and the Klondike for the southern. The Dorsett and Fairfax appear promising for the central and southern sections.

MISCELLANEOUS BERRIES

Not many Juneberries have been planted in this area. As a rule they do not make a very vigorous growth, but appear to be hardy when well established and may be expected to bear considerable fruit. The fruit, while not of high quality, will add an agreeable variety for home use.

Of the wild fruits that are native to this area the buffaloberry is worth consideration, especially for the northern sections, where the range of fruits that can be grown is more limited than in other parts of the area. The fruit is small and very sharply acid. Its most important use is probably for making jelly, though it is eaten in the fresh state to a limited extent.

The fruit-producing blossoms of the buffaloberry are borne on separate plants from those that bear the pollen-producing blossoms. As only the former bear fruit, bushes for planting should be largely of that type, though a small proportion of the others must also be planted to supply pollen for the fertilization of the fruit-producing blossoms.

Selections of the highbush cranberry are suggested for the central and northern sections.

GRAPES

There is very little definite knowledge concerning the possibilities of grape growing in this area. Low temperatures in the north are largely prohibitive, but in some parts of the other sections it is probable that a measurable degree of success could be obtained, especially in localities where wild grapevines are found. Many varieties have been tested in recent years at certain of the dry-land agricultural field stations in the southern part of the area. Some of the varieties that have given promising results include: America, Beacon, Captain, Carman, Catawba, Delaware, Edna, Ellen Scott, Extra, Fern Munson, Headlight, Muench, R. W. Munson, and others. Beta and Alpha are hardier and can be grown farther north than most other varieties.

MIXED PLANTING ADVISABLE

Attention should be here called to the fact that many varieties of apples, plums, pears, cherries, and other fruits are more or less sterile with their own pollen. Such varieties, therefore, may be unfruitful, even though they blossom abundantly, unless planted in close proximity to other varieties of the same kind which blossom simultaneously with them. While not all varieties are self-sterile, and sometimes those which are so under certain conditions are not self-sterile under others, the matter is of too great importance to be disregarded when planting orchards or fruit gardens. It is therefore always wise to select at least two varieties of each kind of fruit for planting, unless one has good evidence that under his conditions a variety which he desires is self-fertile.

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FARMERS' BULLETIN No. 727
Oct. 1937

GROWING FRUIT FOR HOME USE

IN THE GREAT PLAINS AREA

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FRUIT GROWING in the Great Plains area is a home-making rather than a money-making unit in farm-ranch organization. However, anything that adds to the comfort, satisfaction, and well-being of the home often makes returns far in excess of the money value that can be placed upon it. Not all values of material things are money values.

Though the hazards of spring frost, drought, and other climatic factors in this area are too great to justify the planting of any kind of fruit with a view to its becoming a main money crop, there are few seasons when more or less of a yield of some kind—plum, cherry, currant, gooseberry, or other hardy fruit—can not be produced in most sections. An effort to have home-grown fruit every year is very much worth while. Whenever a fruit garden in this area produces a surplus, there need be no fear of an overstocked market to interfere with its ready sale at good prices. Not infrequently ranchers travel many miles to get fruit from some orchard that has developed a commercial surplus.

Although the general methods of fruit culture do not differ greatly in the Great Plains area from those in other sections, there are details of practice of peculiar importance and precautions which if fully observed may help to counteract some of the naturally adverse climatic conditions. The selection of varieties that are the best adapted to these conditions is also fundamental to success.

Washington, D. C.

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GROWING FRUIT FOR HOME USE IN THE GREAT PLAINS AREA

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CONTENTS

	Page		Page
Introduction	1	Proper distances for planting	11
Sites for fruit plantations	3	Tillage	13
Climatic features of the Great Plains	4	Pruning	16
Preparation of the land for planting	6	Irrigation	23
Nursery stock	6	Orchard pests	24
Handling the stock when received from the nursery	8	Hail injury	25
Planting the trees and other nursery stock	9	Fruit varieties suggested for planting	26
		Mixed planting advisable	34

INTRODUCTION

DURING recent years a transformation of large import has been taking place in the Great Plains area. From a vast territory devoted largely to the grazing of cattle and with a very small population it has become an area in which great quantities of grain and other crops are produced annually, with a corresponding increase in the number of homes. Though some sections are still very sparsely settled, the aspect of the entire area has been materially changed by the influx of people who have come from many different parts of the country.

The Great Plains area is not "a natural fruit country," as those regions in which native fruits abound or where the conditions are especially favorable for fruit production are often called. On the other hand, very few native fruits occur in this area, and comparatively little attention has been given to the planting of the cultivated fruits. However, many of the recent comers are from sections where they have been accustomed to grow what fruit was needed for home use. It naturally follows that in many instances upon establishing new homes in this area they have planted a few fruit trees. As a result there are numerous ranches widely distributed throughout the Great Plains where some attempts are being made to grow a home supply of fruit.

NOTE.—This bulletin is intended especially for those in the Great Plains area who are interested in growing fruit for home use, but some parts of it, especially the discussion about pruning and shaping trees, are of general interest to people living in other sections of the country.

The information is based largely upon the results obtained in a dry-land fruit garden which was established in 1908 at the Dry-Land Agriculture Field Station of the Bureau of Plant Industry, Akron, Colo. Most of the illustrations are from photographs taken in this garden.

This bulletin supersedes Bureau of Plant Industry Circular No. 51, entitled "Fruit Growing for Home Use in the Central and Southern Great Plains."

In a few instances orchards of some commercial importance have been developed. Most of these are the outgrowth of one or more of several conditions: (1) The location has proved to be exceptionally well suited to the growing of fruit; (2) the owner has had considerable experience in fruit growing before coming to this section; or (3) the owner, as he has gained experience here with a small orchard, has found himself better qualified for the details of fruit raising than the ranchers generally, and has gradually increased his fruit interests to good advantage.

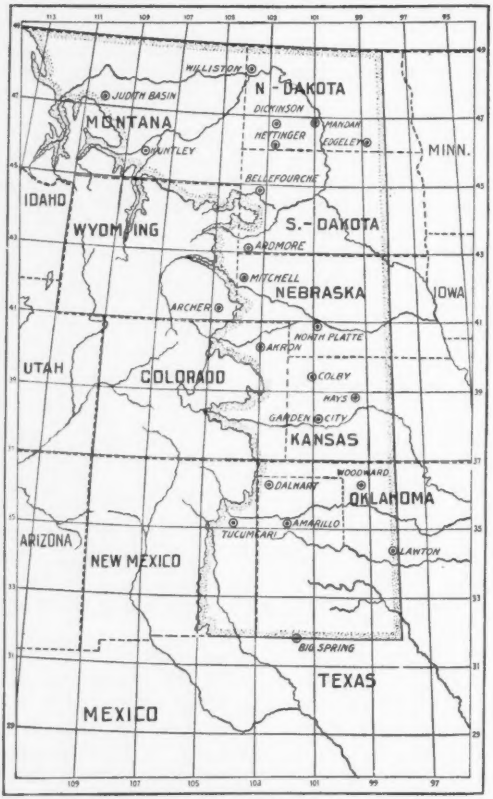

FIG. 1.—Sketch map of the Great Plains area, which includes parts of 10 States and consists of about 400,000 square miles of territory. Its western boundary is indicated by the 5,000-foot contour. Each dot within a circle (⊙) indicates the location of a field station of the Division of Dry Land Agriculture of the Bureau of Plant Industry

The surplus fruit from the home orchards, as well as that produced in those of larger size, always finds a ready sale, buyers sometimes driving many miles to obtain it.

Within the boundaries of the Great Plains area there are a few restricted districts that are under irrigation. In some of these, orchard interests of considerable commercial importance have been developed. These interests are not discussed, however, in this bulletin.

The tree fruits that occur most commonly in the dry-land ranch orchards are apples, cherries, and native plums. In addition to these, in some of the milder parts of the area from southern Kansas southward, the Russian mulberry is common and pears and peaches are quite often to be found; apricots less frequently. In this part of the area grapes are being planted to an increasing extent. Currants and gooseberries are probably the most important as well as the most common of the small fruits. Juneberries, buffaloberries, and strawberries are sometimes to be found.

The successes and failures in this area, as in other sections, are very largely dependent upon the care and attention given by the

owner. In certain regions, however, it is difficult to succeed, whereas in others a complete fruit failure is comparatively rare. The one controlling factor in the Great Plains area, outside of those sections where water for irrigation is available, is the lack of moisture, yet after the trees have become well established it is not often that this causes more than temporary loss, such as a crop of fruit for a single season.

In some sections winds and hailstorms occasionally cause damage, but these losses are not more frequent with fruits than with the field crops. However, the trees sometimes suffer permanent damage from hailstones, even being killed in some cases. Grasshoppers also constitute a hazard of fruit growing in this area, young apple trees, currant and raspberry plants, and other plants sometimes being killed by them in heavy invasions.

The majority of the settlers on the Great Plains must depend upon their own plantations for a supply of fruit for home use. Most of those who do not have home-grown fruit are obliged to do without it. The chief interest, therefore, in the cultivation of fruit in this area centers about the home and the production of enough to meet the needs or desires of each family. In other words, fruit growing here is a home-making rather than a money-making enterprise.

The geographical position and extent of the Great Plains area are shown in Figure 1. Its western boundary, as indicated, is the 5,000-foot contour; its eastern boundary is arbitrarily placed at the ninety-eighth meridian.

SITES FOR FRUIT PLANTATIONS

Probably the greatest obstacle, either directly or indirectly, to the successful growing of fruit in the Great Plains area is lack of moisture in the soil. It follows, therefore, that the site for an orchard or small fruit garden should be selected with a view to securing the maximum supply of soil moisture. In many instances, particularly on the smaller ranches, the conditions are so nearly uniform that there is no choice in this respect. The convenience of the site with regard to the buildings will usually be the ruling factor in such cases.

But on many ranches there are sites that are more favorable for fruits than others on account of the soil-moisture factor; for instance, where a small stream or arroyo passes through the ranch it may furnish an additional supply of water. In some cases the topography is such that a reservoir can be made by building a small dam across the stream and diverting the water to the orchard. Not infrequently some of the larger streams that pass through this area have an underflow that extends some distance on either side. Where this condition prevails and the underflow is reached by their roots, the trees often make a remarkable growth.

Again, there are many instances where the lay of the land is such as to result in a large amount of run-off during heavy rains. If this run-off, which would otherwise be lost, can be collected in small contour ditches and distributed where fruits are planted, a considerable increase in the supply of moisture is secured. A coulee that opens away from the prevailing wind and traps quantities of snow is often an excellent place for an orchard. A shelter belt is almost essential in some places (fig. 21). Advantage should be taken of every factor which will increase or conserve the supply of moisture in the soil.

CLIMATIC FEATURES OF THE GREAT PLAINS

The climate of the Great Plains has been classified as semiarid. It may be better to say that it is variable. One season may have almost humid and another almost arid conditions. The mean annual precipitation is relatively low. Years of relatively high precipitation may be followed by years of relatively low precipitation. Other climatic factors usually correspond with the rainfall. In a year of relatively high rainfall there will be a lower rate of evaporation and higher humidity than in a year of low rainfall.

Another climatic factor of much importance in crop production on the Plains is the distribution of the rainfall. This is probably more important in crop production than the amount of annual rainfall. A relatively low rainfall, properly distributed, may produce a crop where a much higher rainfall, unfavorably distributed, may accompany a crop failure.

TABLE 1.—*Annual and seasonal precipitation and seasonal evaporation at 14 stations in the Great Plains area*[1]

Station	Altitude (feet)[2]	Precipitation (inches)[3]						Seasonal evaporation (inches)[4]		
		Annual			Seasonal					
		Minimum	Maximum	Average	Minimum	Maximum	Average	Minimum	Maximum	Average
Judith Basin	4,228	14.96	23.78	18.06	7.04	17.21	9.34	22.012	29.353	24.491
Huntley	3,000	11.92	11.92	11.92	5.92	6.02	5.79	23.754	24.214	23.984
Williston	1,875	10.28	18.99	14.84	4.75	14.49	9.66	20.422	26.877	24.216
Dickinson	2,543	11.93	21.22	16.69	6.85	16.28	9.79	20.673	25.745	23.919
Edgeley	1,468	11.94	21.95	16.71	7.85	14.98	10.11	18.663	24.893	21.866
Hettinger	2,253	12.72	15.68	14.20	8.92	12.47	10.36	21.539	28.239	24.639
Belle Fourche	2,950	6.64	17.73	13.11	4.08	9.78	6.90	26.472	33.750	28.794
Scottsbluff	3,950	13.77	18.51	16.14	2.53	8.52	4.69	23.804	29.381	26.081
North Platte	3,000	11.18	23.01	18.05	6.85	12.36	9.45	28.445	38.168	32.359
Akron	4,600	14.51	22.46	18.28	6.42	13.86	9.02	26.064	35.654	31.420
Hays	2,050	15.59	27.80	21.30	8.18	17.97	11.17	30.625	44.373	35.790
Garden City	2,900	11.82	23.58	18.54	2.79	14.43	8.65	34.325	43.510	38.185
Dalhart	4,000	13.69	16.35	15.11	5.09	9.85	8.01	35.459	41.748	38.988
Amarillo	3,676	10.69	27.80	18.28	6.17	11.38	9.13	33.804	42.076	36.724

[1] The period of time covered by the investigations made at the several stations ranged from two to eight years, depending upon the time when the different stations were established, the same period being covered by the data regarding precipitation and evaporation shown here.

[2] The altitude given is based in most cases on that of the nearest town.

[3] The records of annual precipitation for 1914 are not included. The records of seasonal precipitation and evaporation for 1914 are included for all stations, being figured from May 1 to Sept. 1. Evaporation measurements are made from a free water surface, in a tank sunk into the soil to almost its full depth. The water surface is kept about level with the surface of the ground

Table 1 gives the maximum, minimum, and average annual precipitation and the seasonal maximum, minimum, and average precipitation and evaporation of the Great Plains area. By seasonal is meant the period between the average time of seeding and the average time of harvest. * * *

Figure 2 shows the earliest and latest dates of the last killing frost in the spring, the earliest and latest dates of the first killing frost in the fall, and the average length of the frost-free period at each station. Each hatched horizontal bar represents the period between the average dates of the last killing frost in the spring and the first killing frost in the fall. The number of days in the average frost-free period for the station is shown in the figures above the bar. The solid-line curve at the left shows the earliest date at which the frost-free period has begun. The broken-line curve at the left represents the latest date at which the last killing frost of the spring has occurred. The solid-line curve at the right represents the earliest date and the broken-line curve at the right the latest date at which the first killing frost of the fall has occurred.

This diagram [fig. 2] shows clearly the increase in the length of the frost-free period from the north to the south. The shortest average period is 100 days, at Hettinger, and the longest 194 days, at Amarillo.[1]

[1] See Chilcott, E. C., Cole, J. S., and Burr, W. W., "Crop production in the Great Plains area: Relation of cultural methods to yields," U. S. Dept. Agr. Bul. 268, pp. 3–4, fig. 2. 1915. Out of print, but may be consulted in libraries.

In the Great Plains area the regional restrictions to fruit growing, so far as the natural conditions are concerned, are primarily factors of temperature and moisture.

In some sections of this area, especially the northern part, fruits for planting must be selected with a view to their hardiness and their ability to endure extremely low temperatures in winter. But throughout the Great Plains area as a whole unseasonable frosts during the blossoming period or at other critical stages of growth more often cause damage than extreme cold during the dormant period; also, extreme fluctuations in winter temperatures sometimes result disastrously. Warm spells sometimes occur, followed by sudden cold snaps which ofter cause more injury to supposedly hardy species or varieties than steadily continued extreme cold. However, the combination of relatively low winter temperatures, limited moisture supply, and drying winds that sometimes prevail is extremely trying on most fruit trees and may cause serious damage where any one or even two of these factors operating at the same time would not adversely affect the trees.

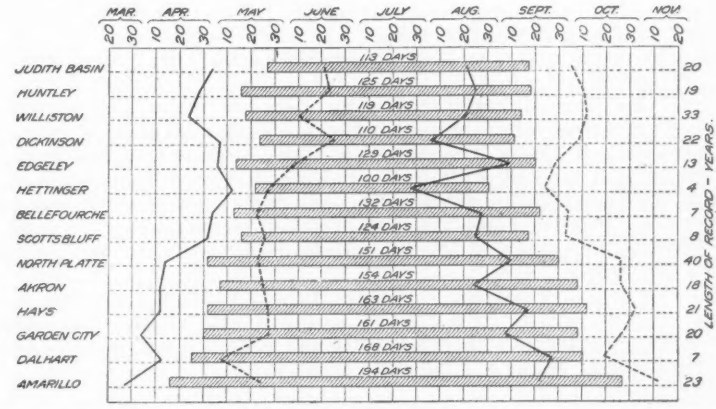

FIG. 2.—Diagram showing the average frost-free periods and the earliest and the latest dates at which the last killing frost in the spring and the first killing frost in the fall has occurred at 14 stations in the Great Plains area

The general climatic features of this area are well indicated in the paragraphs above quoted. In that connection the statements are applied to the production of general agricultural crops, but they are none the less applicable to fruit growing.

Another climatic factor that occasionally does great damage is hail. Trees of considerable size are sometimes completely killed or so badly bruised or otherwise injured as to render them worthless. Hailstorms occur much more frequently in some parts of this area than in others. In sections where they are known to be severe, the planting of fruits is likely to prove disappointing.

Some sections of the Great Plains are further characterized by winds which blow almost continuously. While the wind may not be a prohibitive factor in the growing of fruit in any section it is a serious one where it blows much of the time. It not only results in the premature dropping of the fruit, but it becomes practically impossible to prevent the tops of the trees from growing very much to one side.

PREPARATION OF THE LAND FOR PLANTING

For fruits, land that has been in cultivation for one season or for a sufficient length of time for the sod to have become thoroughly rotted is very much to be preferred to newly broken land.

The planting of fruits in this area should be done as a rule in the spring, and in any special preparation that may be made the aim should be to handle the soil so that it will contain as much moisture as possible at the time the planting is done.

In seasons of fairly abundant precipitation, especially if there is considerable rainfall or fairly heavy snows during the winter, there may be enough moisture stored in the soil in the spring to insure the starting of the trees, even if a crop has been produced the previous season. But because of the wide seasonal variation in the amount of precipitation, frequently falling far below normal, and the importance of an abundant supply of soil moisture in the spring at planting time, it is generally advisable to summer-fallow during the season that precedes the planting.

In addition to summer fallowing, an adequate supply of soil moisture is still further insured if deep furrows are opened in the fall along the lines of the tree rows. These will serve to collect both the drifting snow and some of the run-off during heavy rains which might otherwise be lost.

One very successful fruit grower on a dry-land ranch even supplements the furrows by digging in the fall rather large holes where the trees are to stand. The run-off, as well as the snow caught in the furrows, will tend to settle in the holes and thus still further augment the amount of moisture in the soil in the immediate radius of the trees. In some cases, cross furrows or furrows made at an angle to the direction taken by the run-off and leading to the holes might also be useful.

Under ordinary climatic conditions this method of preparing the land should result in its being well supplied with moisture, and the trees should start into growth readily and make a good development of roots so far as the soil moisture is concerned.

NURSERY STOCK

In the central portion of the Great Plains area, as represented by the United States Dry-Land Field Station, Akron, Colo. (fig. 1), the most favorable period for planting is usually the last of April and early in May. It varies in other parts of the area from earlier in the southern section to somewhat later farther north. Normally, nursery stock is delivered in the spring rather than in the autumn. It is absolutely essential for success that it reach its destination in a perfectly dormant condition. Hence, it follows that while it may be satisfactory for those ordering stock for planting in the southern part of the area to secure it from northern sources, it is not well to obtain it from the south for planting in the northern sections, on account of the fact that the buds may start on stock from the south before the most favorable period for planting in the north has arrived.

On account of the arid or semiarid conditions of this region the period following the planting of the trees is very trying unless there

is a sufficient supply of moisture stored in the soil and available for their use. The moisture in the trees is being dried out constantly, and more rapidly than would be the case in a humid region. The roots of newly planted trees do not at first readily take up moisture from the soil, and if it is excessively dry the trees may die before they can start into growth. Because of these moisture factors it is of the greatest importance to procure only trees and other nursery stock which are most likely to start into growth readily and quickly when planted.

In many fruit-growing regions apple, pear, plum, and cherry trees are commonly planted when 2 years old; that is, after they have made two seasons' growth in the nursery from the bud or graft. However, in some commercial apple and cherry growing sections there is a strong sentiment in favor of 1-year-old trees for planting in preference to older ones. The younger trees have an advantage in that it is possible to form the tops at any desired height. The heads are already formed on 2-year-old trees when received. Not infrequently the trees have been headed too high to be desirable, and it is not always possible or practicable to plant such trees deep enough to overcome this objection. And, again, good, strong 1-year-old trees, as a rule, withstand transplanting fully as well as older trees; they are lighter to handle in shipping and in other ways are more desirable. This is true of other trees as well as of apples and cherries.

Inexperienced buyers of fruit trees not infrequently measure the value and grade of the trees delivered by their size; the larger the tree the better it is supposed to be. But experience has proved that thrifty, medium-sized trees are better for planting in the Great Plains area than larger ones, with a preference for good, strong 1-year-old trees. The larger 2-year-old trees as a rule do not withstand transplanting as well, nor are they as likely to live and make a good growth as the medium-sized ones of the same age.

On the other hand, a very radical distinction must be made between medium-sized or relatively small healthy trees and those which are small because they have been stunted by some adverse condition. Weak, stunted trees should be refused absolutely. They are likely to be expensive even as a gift.

Good root systems are also of special importance in satisfactorily starting trees planted under the conditions which normally prevail in this area. In sections where all the factors influencing growth are favorable, the difficulties incident to poor roots, if not too serious, may be overcome perhaps without permanently harmful results; but in the region under consideration well-developed and abundant root systems are especially important. If the roots of trees consist of only a very few large parts, new growth does not start as readily and as quickly as it does if the plants are well provided with a large number of small roots.

But here again caution is necessary. A large mass of very fine threadlike roots is due cause for suspicion. Such roots may indicate a disease known as hairy-root, a form of crown gall. Although there is a wide difference of opinion and experience concerning the seriousness of this trouble, it is by far the safer plan to discard trees so

affected; the roots in any event are abnormal and if planted there is always the possibility that the trouble will develop to such an extent as to affect seriously the vigor and durability of the tree. All trees and vines showing crown gall or abnormal growths of any kind should be rejected.

The height of the tree is as important as its root system. Trees that have been headed from 1½ to 2½ feet high as a rule start into growth more readily and develop better than trees headed 3 to 3½ feet high. In a large majority of cases the high-headed trees, even when they live, make only a very small growth the first season and rarely develop well-formed, satisfactory tops as they increase in age.

HANDLING THE STOCK WHEN RECEIVED FROM THE NURSERY

It has already been stated that planting in the spring rather than in the fall is to be advised in this area. To insure the timely arrival of the stock from the nursery it is wise to order it shipped with a view to its arriving at its destination a little in advance of the actual date of planting. Otherwise, an unexpected delay in shipping or during transit may result in inconvenience or in the undue starting into growth of the stock before it is received.

To hold trees and other plants in good condition until planted, they should be unpacked immediately upon arrival and heeled in without delay in a well-drained spot. The heeling in is accomplished by digging a trench 12 or 15 inches deep, sloping on one side. The roots are placed in the trench, the trunks of the trees lying at right angles to it on the sloping side. The position is illustrated in Figure 3. In case the trees are tied in bundles when received they should be separated; otherwise, the roots can not be properly protected. Moist, finely pulverized soil should then be worked thoroughly in among the roots, completely filling all the spaces, and the roots finally covered several inches deep.

If it is necessary for any reason to have the trees heeled in for a long time before they are planted, it may be advisable to cover the tops, entirely or nearly so, with soil, to prevent the sap from being dried out to an undue extent. With the first advent of warm weather, however, the branches should be uncovered.

The soil that is placed over the roots and such other parts of the trees as may be covered should be packed very firmly. This is not only for the purpose of excluding as much air as possible, but to lessen the danger of mice finding a harbor among the trees, where they might cause injury by gnawing the bark.

Trees that are heeled in should be examined frequently, with especial reference to moisture conditions. While the soil about the roots should not be kept in a water-soaked condition, it should not be permitted, on the other hand, to become thoroughly dry. The sap in the trees would be likely to dry out and the bark shrivel if this should occur. Difficulties of this sort can be avoided easily by the judicious application of water.

Berry bushes and other small fruits are handled in essentially the same manner as trees, but the trenches in which the roots are placed are shallower than for tree fruits, to correspond with the size of the plants.

PLANTING THE TREES AND OTHER NURSERY STOCK

The most satisfactory time for planting fruit trees and bushes in eastern Colorado in the average season is the last of April or the first of May. The soil is usually in good workable condition at this time, and as a rule it is a period during which there is considerable precipitation. These conditions are favorable for growth, and if a tree or other plant reestablishes itself readily in its new place and growth begins promptly one of its most critical periods is past.

The best time for planting fruits in the other parts of the Great Plains area may vary somewhat from the dates for Colorado given above. Generally, it may be done earlier in the southern sections and later in the north. It should be done after the danger of hard

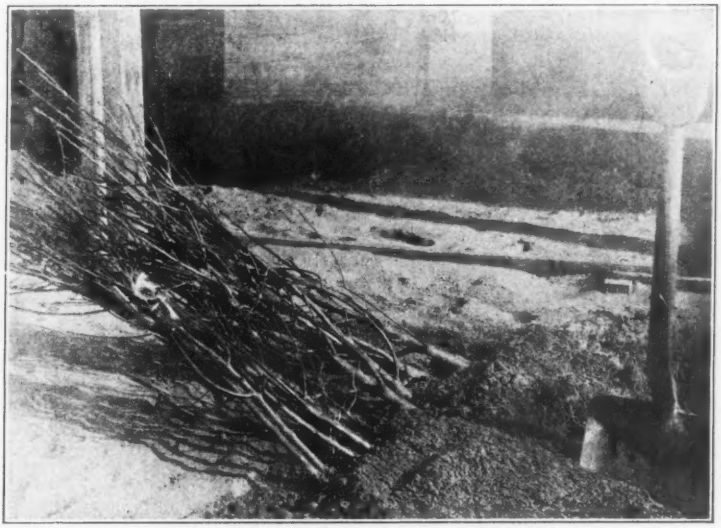

FIG. 3.—Peach trees heeled in. The position in which the trees are placed is to be noted

freezing temperatures is past and when the soil is in good condition for working; otherwise, the earlier the better, usually.

The method of planting fruit trees in this area does not differ in any essential from that commonly followed in other parts of the country. In handling the trees every possible precaution needs to be taken to prevent the roots from becoming dry when the trees are removed from place to place. The roots should not be exposed to the air more than is absolutely necessary. Covering with wet burlap is, perhaps, the most convenient means of giving protection, but wet chopped straw, damp moss, or other materials that can be moistened and covered over the roots may be made to serve the purpose; or the roots may be protected by puddling them. This consists merely in dipping the roots in a puddle of clay. The clay should be of such consistency that a thin layer of mud will adhere to the roots when they are dipped into it and at the same time per-

mit them to be moved about in it with perfect ease and freedom. Such a coating of mud will afford considerable protection against undue drying out from exposure to sun and wind. By observing this precaution at all times, including the period of exposure incident to planting the trees, there should be no loss due to dried-out roots.

The holes are made broad enough to receive the roots without bending them from their natural position and deep enough so that when filled even with the surrounding surface the trees will stand 2 or 3 inches deeper than they did in the nursery. Sometimes the holes are made in the fall, as previously described.

Before planting, the ends of all broken roots and roots otherwise injured should be removed with a smooth cut. As the trees are placed in position in the holes the soil is carefully worked around the roots and firmly packed by tramping. If the soil is moderately moist it will not be necessary as a rule to water the trees when planted; but if the soil is dry it may be well to pour a pail or two of water into the hole after it has been partially filled with soil, and then complete the filling after the water has soaked in. The subsequent use of water should be governed by conditions. If it continues dry after the trees are planted an occasional application of water sufficient to keep the soil in the vicinity of the roots well moistened may enable the trees to grow readily when otherwise they might fail entirely from lack of moisture.

When the trees are planted they should be headed back to the desired height. It is believed from experience and observations under Great Plains conditions that the main stem or trunk of the tree should not exceed 2 or 2½ feet in height, measuring from the surface of the ground after the tree is planted. In many cases the heads may well be formed even lower than this. Trees with low heads are not as likely to be injured by sun scald as those with high heads, nor are they as much affected by the wind. If the trees have been headed in the nursery, as is the case with stock 2 years old, it is often impossible to handle them so as to place the heads at the desired height. With 1-year-old trees this difficulty does not exist.

There is a wide difference of opinion and practice among fruit growers as to the details to be observed in shaping the permanent head of the tree, but the conditions attending tree growth in this area are such that it is believed an open head which develops from a few main branches is preferable to one so managed that it becomes dense and bushy.

To develop an open head, only four to six branches should be left when the tree is pruned at the time it is planted, or when it is formed later if 1-year-old trees have been used. These branches should be selected with a view to their position on the trunk. They should be arranged symmetrically and spirally about the trunk and should start from different levels, thus leaving some space vertically between the different limbs. If two limbs branch from the trunk at the same level there is much more danger that they will split down in later years under the weight of a large crop of fruit or during a heavy wind than where the formation is as here suggested.

The branches selected for the permanent top of a 2-year-old tree should be cut back considerably at the time the tree is planted. If the

tree has made a fairly vigorous growth in the nursery the preceding season, one-half or two-thirds of the length, as a rule, may be cut away. This will tend to make the branches strong and stocky rather than slender and "leggy," as when no cutting back is done.

This plan of forming the head also reduces the number of branches which the roots are required to supply with moisture during the first season's growth. It should be kept in mind that a considerable portion of the root system is lost in digging the tree from the nursery and that the branches need to be reduced proportionally.

The plan described is illustrated in Figure 4 and still further shown in Figures 5 to 10. Figure 4 shows a McIntosh apple tree in July of its second season's growth in the Akron fruit garden. It was headed low, the number of permanent branches was reduced to four or five, and from the very beginning the top has been kept open. The same plan of development may be seen in the other illustrations mentioned.

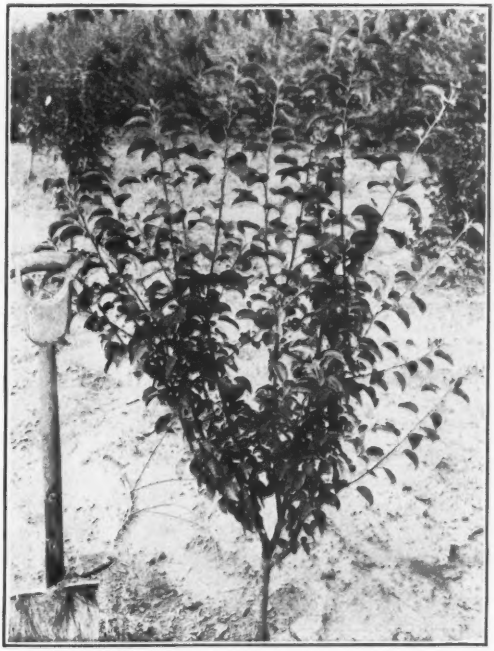

FIG. 4.—A McIntosh apple tree in July of its second season's growth, which has been pruned with a view to developing an open head. Akron, Colo.

The method followed in planting small fruits is essentially the same as that described for tree fruits. They are planted, as a rule, a little deeper than they were originally. They are cut back, if necessary, to make the tops correspond to the root system, and in other respects the directions given above are readily adapted to handling small-fruit plants.

Because the roots of small fruits are nearer the surface than those of tree fruits it may be necessary to give more attention to watering newly set plants until after they start into growth than is suggested for trees. This applies with special emphasis to strawberries.

PROPER DISTANCES FOR PLANTING

The distance between fruit trees is a matter of greater importance than is commonly realized. The space unoccupied at the time the small trees are planted seems out of proportion to their size, but the

requirements when the trees are mature must be anticipated. It should be remarked that the roots extend very much farther than the spread of the branches, contrary to a commonly expressed notion. At Cheyenne Wells, Colo., the roots of a 14-year-old apple tree were traced 26 feet in one direction from the tree and some 9 or 10 feet in the opposite direction, making a spread of at least 35 feet; in fact, the actual spread was several feet more than this, as it became impracticable to trace the roots in the very dry, hard soil to their ends.[2] The great number of roots that develop on apple trees under semiarid conditions is suggested by Figure 11, and the expanse of the roots is shown in Figure 12. It was 26 feet from the stump to the

FIG. 5.—A Delicious apple tree after two seasons' growth as it appeared before its annual pruning. The foundation for the top consists of four or five main limbs

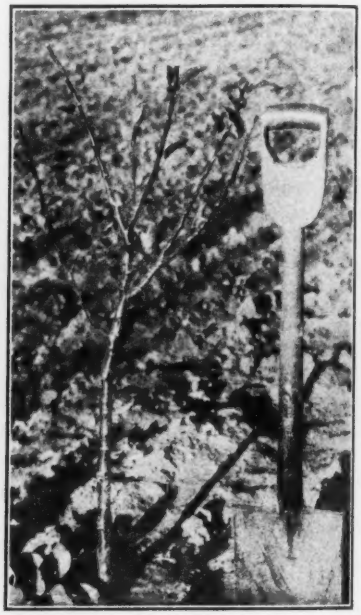

FIG. 6.—The Delicious apple tree shown in Figure 5 after being pruned. Both figures were reproduced from photographs taken at Akron, Colo., in November

end of the root held by the man shown on the left in the illustration (fig. 12).

It therefore appears that trees in their earlier life may suffer more from the crowding of the roots than from the crowding of their tops. The bearing which these facts have on the welfare of the trees is largely in relation to the moisture supply. If the trees are too close together their combined moisture requirements may exceed that furnished by normal precipitation.

[2] This study of the root systems was made in August 1910 at the Dry-Land Substation of the Colorado Agricultural Experiment Station by J. E. Payne, then connected with that station, and by the senior author of this bulletin. For further details, see Colo. Agr. Expt. Sta. Bull. 173, Notes on a dry-land orchard.

Too close planting is a common fault in many of the commercial fruit-growing districts in irrigated as well as in humid sections. Its results in semiarid sections where irrigation is not practiced are likely to be particularly serious.

Although fruit trees may not grow as large under the semiarid conditions of the Great Plains as in humid sections, it is not believed that this fact is sufficient to warrant close planting. On the other hand, the size attained here by trees is likely to be governed very largely by the amount of moisture available.

FIG. 7.—The same Delicious apple tree shown in Figures 5 and 6 as it appeared in July of the following season. The buds near the ends of the stubs in Figure 6 have developed into branches, thus making a good framework for the development in the future of a strong, well-branched tree. Akron, Colo.

In the light of the foregoing statements, the following distances each way for the planting of different fruits are suggested:

Apples, 30 to 35 feet.
Pears, 25 to 30 feet.
Peaches, 20 to 25 feet.
Plums, 20 to 25 feet.
Cherries, 20 to 25 feet.
Sand cherry-plum hybrids, 10 to 15 feet.
Currants, 5 to 6 feet.
Gooseberries, 5 to 6 feet.
Raspberries, 6 to 7 feet.
Blackberries, 6 to 7 feet.
Strawberries, usually in rows 3 or 3½ feet apart, with the plants 1½ to 2 feet apart in the row.

Many of these distances may seem excessive at first, but they allow none too much space when the demands of mature trees and other plants for moisture and plant food are taken into account.

TILLAGE

The tillage (or cultivation, as it is more commonly termed) of a fruit garden or orchard in this region should be thorough. Its primary objects are to maintain the surface of the soil in a granular condition, so that it will readily absorb all of the rainfall, and to prevent the growth of weeds. A dust mulch does not take up the moisture as freely as a granular surface does, and is very subject to blowing.

The other objects of tillage will generally follow as a matter of course. Usually it should be continued fairly late in the season.

During one year seasonal cultivation in the dry-land ranch garden at Akron was discontinued early in August in order to avoid further stimulation of growth and to insure a thorough ripening of the wood before the advent of cold weather. However, no beneficial results followed that could be attributed to the cessation of cultivation as early as this; and, besides, it might prove a rather hazardous plan in some seasons. The growth of weeds following the cessation of cultivation so early in the season was sufficient to make a serious drain on the supply of soil moisture. The danger lies in the fact that the moisture in the soil might be reduced

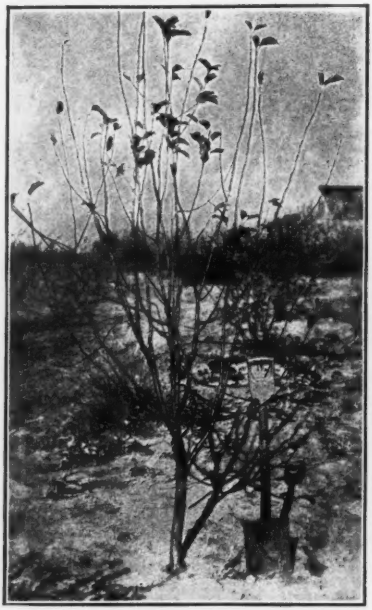

FIG. 8.—An Utter apple tree after its third season's growth as it appeared before its annual pruning. In previous years the pruning has been directed toward keeping the top open

FIG. 9.—The Utter apple tree shown in Figure 8 after being pruned. Both illustrations (Figs. 8 and 9) were reproduced from photographs taken at Akron, Colo., in November

to such an extent that the trees would suffer during the winter or the following season in case there was little precipitation.

Tillage in the garden at the United States Dry-Land Field Station has been frequent enough to destroy weeds before they have made any considerable growth, to prevent the soil from blowing, and to insure against any run-off during heavy showers. To these ends the surface has been kept in a rough, granular condition. Tillage has usually been continued until the latter part of August, or late enough to prevent any considerable growth of weeds and to avoid all danger of their going to seed.

This practice with regard to tillage has given good results in the Akron garden. Moreover, in its general principles it has been followed by ranchers in other sections of this area in the successful growing of fruit. Slight modifications of this plan of tillage may be necessary under some soil and climatic conditions, but it is believed that it embodies the essential features, so far as this operation is concerned, in maintaining orchards and fruit gardens in this area, not only while they are young but after they reach maturity.

Clean tillage throughout the season during the early life of an orchard amounts practically to summer fallowing. During the first three or four years and before the roots have extended very far, the demands made by the trees upon the soil moisture are comparatively small. With normal precipitation the tendency obviously would be for the percentage of soil moisture in the spaces between the trees to increase rather than to decrease under this method of management. In this way, the greater demands of the trees for moisture as they reach larger size are anticipated in a measure, at least for a time.

FIG. 10.—The same Utter apple tree shown in Figures 8 and 9 as it appeared in July of the following year. Akron, Colo.

Cover crops and green-manure crops serve a most important purpose in maintaining the fertility of orchard soil in humid and irrigated sections, but in this area where the soil moisture is so largely the limiting factor their use rarely, if ever, can be advised. The growing of these crops usually would draw so heavily upon the moisture in the soil that they would be a menace rather than a benefit to the fruit. The humus furnished by such crops in sections where they can be grown must be supplied here by applying manure or vegetable matter in some other form.

For a similar reason the interplanting of crops between the rows of trees in young orchards, as is commonly done in commercial fruit-

growing sections, can not be recommended in this area. In the case of apple trees planted 30 or 35 feet apart, a row or two of corn or some vegetable possibly could be planted for the first two or three years midway between the rows of trees without irreparable harm to the latter, but the wisdom of even this limited competition with the trees would usually be doubtful.

The tools used in cultivating fruits may be a disk harrow, corn cultivator, or shovel cultivator, as conditions or convenience may dictate. While there are specially constructed orchard-tillage implements, the same tools used in the cultivation of general crops may be used advantageously in most cases.

FIG. 11.—Part of the root system of a 14-year-old Ben Davis apple tree. Colorado Experiment Station, Plains Substation, Cheyenne Wells, Colo., in August

PRUNING

There is probably no phase of fruit growing on the Great Plains which requires greater care and attention in order to obtain the best results than the operation of pruning. Although this is especially true of tree fruits it is also of importance with small fruits.

One of the commonest faults to be found with fruit trees on many ranches in the Great Plains area is the density of the tops. This fault, however, is not more characteristic of fruit growing in this area than it is in many other parts of the country. It is a natural consequence in the first place of planting trees without properly forming the heads at the time they are set out and of improper pruning or no pruning at all in after years. In fact, as will be illustrated later, it is often practically impossible to correct the faults incident to improper pruning at the time of planting by pruning when the trees are several years old.

If only a single idea were to be kept in mind in pruning a fruit tree throughout its life, that idea might well be to keep the top sufficiently open to admit air and sunshine freely. If this is accomplished, most of the other objects for which fruit trees should be pruned will also be realized.

The fear that the branches will be injured by exposure to the sun is frequently offered as a reason for allowing the tops to become very dense. It is true that where a large limb which has been shaded continually is suddenly exposed to the direct rays of the sun serious injury may result, but when a tree is grown from the beginning with an open head and is properly pruned there is little danger from this cause.

In further understanding the principles of pruning, the reader will be assisted by reference to the accompanying illustrations, most

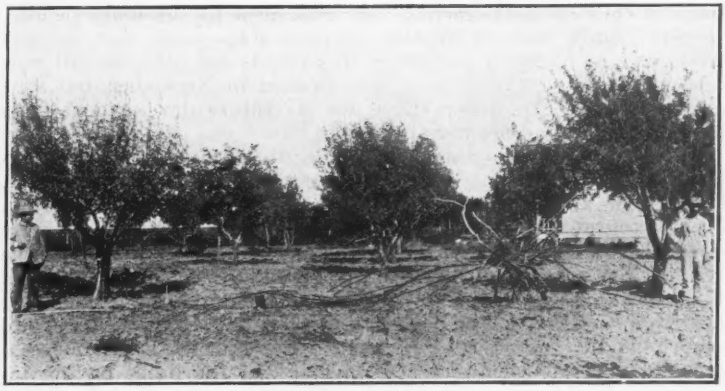

FIG. 12.—The same stump of a Ben Davis apple tree shown in Figure 11. The roots were traced a distance of 26 feet on the left and 9 or 10 feet on the right. The small extremities of the roots, amounting probably to several feet in length, still remained in the soil

of which are made from photographs taken in the Akron fruit garden.

Figure 4, previously referred to in connection with the planting of trees, shows also the pruning which was done following the first season's growth. The limbs were cut back to the points just below the level of the upper part of the spade handle, where the secondary branching may be seen. Branches which may have crossed each other and other superfluous growth were also cut out. While the top is open, it will be observed that the main limbs are well protected by leaves that developed from short spurs or buds. In a very dense top there would be but little development of leaf-bearing spurs along these limbs. The photograph reproduced here was taken in July. A good strong current season's growth is evident. This growth would normally be headed back during the following dormant season, and such thinning out as might seem necessary to maintain the top in a well-opened condition would be done at the same time.

Figure 5 shows a Delicious apple tree that was planted in the spring. The top was lightly pruned in July of the same year, the superfluous branches being removed. This figure shows the tree as it looked in November of the following year. The current season's growth of some of the branches was 2 to 3 feet, with practically no side branches. Figure 6 shows the same tree after it had been pruned. The results of this heavy heading back in November become apparent by reference to Figure 7, which shows the same tree the next July.

The strongest growth has taken place from buds near the ends of the stubs of branches shown in Figure 6. This is resulting in a well-proportioned stocky tree, yet one which can be kept well opened to the air and sunshine with a minimum amount of pruning. Had this tree been left, as shown in Figure 5, without heading back, the branching the next season probably would have occurred from buds near the ends of the branches, thus making a top of long, slender, "leggy" limbs instead of the compact framework that is seen developing in Figure 7. Perhaps this tree is not quite as tall now as it was in Figure 5 before it was pruned in November, but it is more stocky and in better shape for its future development than it would be if it had not been headed back.

Figures 8 and 9 illustrate still further the idea expressed in Figures 4 to 7 with reference to developing trees with stocky open tops. These show an Utter apple tree that was planted in the spring. The photographs from which these illustrations were made were taken in November two years later, before and after pruning. The tree had then completed three seasons' growth. From the beginning, it has been handled with a view to keeping the top open. As may be seen from Figure 8, in comparison with Figure 9, it was necessary to remove but little wood at this pruning, even though the current season's growth had been very strong, many of the limbs having increased 2 feet or more in length. The tree was started with a framework of four or five branches. With these as a foundation and with a small amount of corrective pruning each year the tree remains under easy control.

In contrast with the average apple tree to be found in this area, the one shown in Figure 9, as it here appears, may seem to many to be entirely too open. During the next season, however, the development of leaves and many small side branches, which may be expected eventually to form fruit spurs, causes the tree to present a very different appearance, as shown in Figure 10. As seen here it is in its fourth season's growth. It will not be headed back very much in the pruning which it receives in the future. Heavy heading back tends to stimulate additional wood growth. This tree has now been well shaped. The limbs that form the framework of the top, as well as the trunk, are stocky and strong. It is in good condition to begin to bear fruit. There is, therefore, no further need of pruning to encourage additional wood growth, but more or less thinning out of the top probably will be necessary each year. Slight heading in at times may be advantageous, but the foundation work, so far as pruning is concerned, has now been completed.

The keeping of the top well opened during the first few years is favorable for the development of spurs and short branches along the

limbs, thus tending to the production of a large bearing surface. It is on such growth that many fruit buds subsequently develop. This so distributes the fruit on the main limbs that there is the least possible danger of their breaking from its weight.

It should be stated, however, that there is much yet to be learned about the effect of heading back the annual growth year after year. If trees with strong stocky limbs are to be developed, rather heavy heading in for several years after planting seems as a rule to be necessary. On the other hand there is considerable evidence that if this practice is carried too far it very materially retards the time of bearing. Moreover, in this respect, it seems probable that trees of different varieties should be handled differently. Some varieties naturally make a strong stocky growth and do not branch excessively, while others develop long, slender branches. Obviously these two types of trees should be treated differently with respect to pruning.

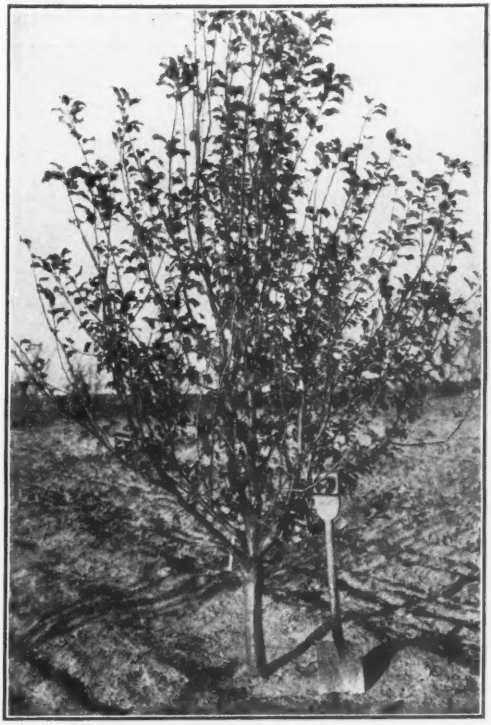

FIG. 13.—A Wealthy apple tree planted in the spring, which received no further pruning until after its third season's growth. Because of these years of no pruning it was not possible in later years to bring the top to a desirable form. Akron, Colo., November

It is, of course, desirable that a tree should come into fruiting as early as possible after it is planted, but the gain of a year or two in earliness of bearing is of small importance compared with the development of a type of tree which in later years will best meet the ends for which it is grown. It is the nice balance between earliness of bearing and other characteristics and the development of a tree which in the long run shall be best suited to fulfill the ends in view that constitutes the real problem in pruning during the early life of an orchard.

In rather strong contrast to the trees shown in Figures 4 to 10 are those in Figures 13 to 17. The latter illustrate apple trees that were planted in the spring. The photographs used in making

these illustrations were taken in November after the trees had completed their seventh season's growth. Because these trees are considerably older than those shown in Figures 4 to 10, the illustrations in the two groups are obviously not entirely comparable. Yet they show certain contrasts that are of fundamental importance in pruning fruit trees at the time of planting and during the first three or four years thereafter.

In contrast to Figures 4 to 10, Figures 13 to 17 show apple trees that were not trimmed with any particular ideal in view when they were planted, and they received no further pruning until after they had completed their third season's growth. After that time they were pruned each year. To the casual observer the objectionable features of these trees may not be conspicuous, but they become very real to one who wishes to prune them in a rational manner.

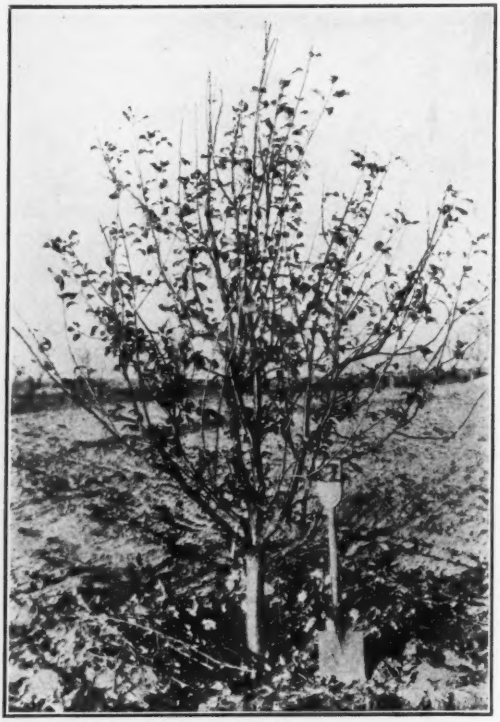

FIG. 14.—The Wealthy apple tree shown in Figure 13 after being pruned. Akron, Colo., November

Figures 13 and 14 show a Wealthy apple tree and Figures 15 and 16 a Patten tree in November, before and after pruning. Figure 17 is a Northwestern Greening apple tree not yet pruned. It will be seen by reference to the figures showing the trees before pruning that the tops are not extremely dense, as at the time the photographs were taken a good deal of the foliage had dropped. When the pruning was begun after three years of unrestricted growth, the tops of these trees were veritable heaps of brush. The pruning after the third year of growth was directed primarily toward the gradual removal of superfluous wood. However, because of the fact that the trees were not well formed at the time they were planted and during the first year or two thereafter, the pruning in subsequent years has failed and must continue to fail to reduce the work to the simple systematic operation that it is in the case of trees that are well pruned from the beginning. Most of the branches in these three trees (figs. 13, 15, and 17) are relatively long

and slender because they radiate so largely from a common axis or nearly from a common center. To keep the tops suitably pruned is difficult. If one of the larger limbs with its component branches is removed to open the top, the result is an unsymmetrical head; one side is made considerably lighter than the other.

The alternative in maintaining the tops sufficiently open for the free access of sunshine and air is to cut away a considerable number of the smaller branches. This tends toward the development of long slender unbranched limbs, with the bearing surface a little later in the life of the trees occurring only near the extremities.

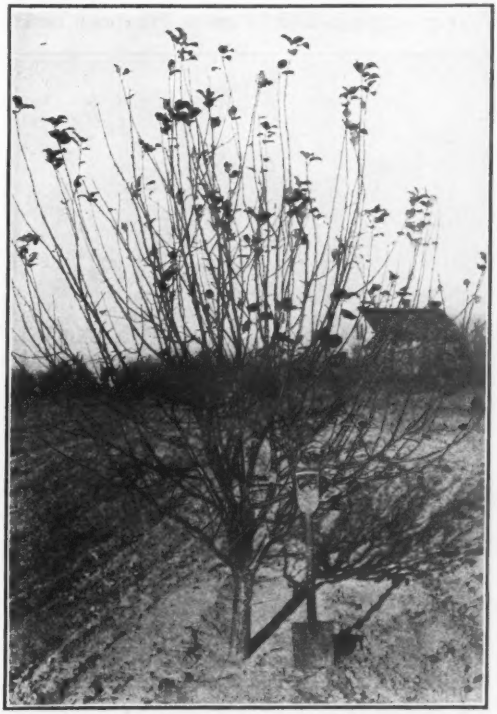

FIG. 15.—A Patten apple tree planted in the spring, which has received treatment similar to that of the Wealthy apple tree shown in Figure 13. Akron, Colo., November

The point in question is especially evident in Figure 17, where the tendency to make long slender growth is very conspicuous, in spite of the effort made during three or four years to put the tree into the best shape that its condition permitted.

A study of the illustrations here used emphasizes the fact, which all fruit growers recognize, that the natural habit of growth of different varieties must be considered in intelligent pruning. The upright habit of the Wealthy tree (figs. 13 and 14) and the roundish form of head shown by the Patten (figs. 15 and 16) and the Northwestern Greening trees (fig. 17) make the problem of pruning these two types quite different in each case, even though the principles involved are the same. The Utter tree in Figure 8 shows still another type of growth in that, even if left entirely unpruned, the top would not be likely to become as dense as that of the other varieties illustrated, because it does not branch so profusely. It is therefore less trouble to keep it well pruned, though the principles are the same as in pruning trees of the more profusely branching type.

The manner of pruning other fruit trees does not differ in principle from that followed with apple trees. Ordinarily the tops of

plum and cherry trees are not kept quite as open as apples, principally because of the greater natural tendency to form fruit spurs along the branches; but if due attention is not given to the proper forming of the tops when planted and to wise pruning subsequently, the same troubles as those detailed for apples are sure to follow. This fact is made evident by Figure 18, showing a native plum tree six years after being planted, which formed a head so dense that it was only with considerable difficulty that the fruit on the interior of the tree could be picked. Figure 19 is a Desoto plum tree a year younger. This variety does not make naturally as dense a growth as does the one in Figure 18; besides, it was planted one year later, so that it began to receive systematic pruning that much earlier in its life. These plum trees were headed back to some extent during the three or four years before they were photographed, but they will not be likely to require very much more heading back.

FIG. 16.—The Patten apple tree shown in Figure 15 after being pruned. Akron, Colo., November

The Early Richmond cherry tree in Figure 20, the same age as the Desoto plum, has responded fairly well to the corrective pruning that it received after it was 3 years old.

Another problem in pruning is suggested by the tree shown in Figure 21. In some parts of the Great Plains area rather strong winds blow much of the time. The influence of such winds can be more or less checked as a rule by growing a well-arranged system of shelter belts that extend across the path of the prevailing winds. A little can be accomplished also by pruning. The branches should be kept well headed in. This heading in may need to be done during the growing season if a long slender growth is being developed and it is being continuously forced far from its normal position. The top, if kept well opened, will offer less resistance to the wind than where it is allowed to become dense. Besides, if the tops are not too dense the branches will probably be less impeded in resuming their normal positions when the wind is

not blowing. However, a complete counteracting of the influence of strong prevailing winds is hardly to be expected except as the force of the winds is broken by shelter belts of some kind.

Great emphasis has been placed on pruning with a view to keeping the tops open. There are other reasons why systematic annual pruning should be done. Without regard to the order of relative importance, the more evident reasons may be enumerated as follows:

(1) Every branch is reaching out for sunlight. If the top is sufficiently open so that every leaf receives its full complement of sunshine there is less competition among the different branches than where the top is very dense.

(2) With the decreased struggle for existence among the branches, the crowding of the weaker ones and the resulting dead wood in the top of the tree are largely eliminated.

(3) The development of fruit-bearing spurs well within the center of the tree is encouraged because they receive sunlight, and sunlight in full measure is essential to healthy, vigorous growth.

(4) When a tree reaches bearing age it can be sprayed thoroughly, and it is evident that spraying will be necessary in this area if good fruit is to be grown. Besides, the fruit can be picked with reasonable ease and comfort. But not so if the picker must crawl through a brush pile to reach it.

(5) The above reasons are common to all fruit-growing regions. Another is of special significance on the Great Plains because of the limited rainfall. The conservation of the moisture in the soil is of the greatest importance. Great quantities of moisture are taken up by a tree and given off through the foliage. In general, the greater the amount of foliage the more rapidly is moisture given off. By proper pruning and thereby the holding of the top to a form or condition as to the number of branches and the amount of foliage which are most consistent with the objects for which the tree is desired, the less will be the loss of moisture from the soil through the foliage. Hence, it follows that wise pruning helps to conserve soil moisture.

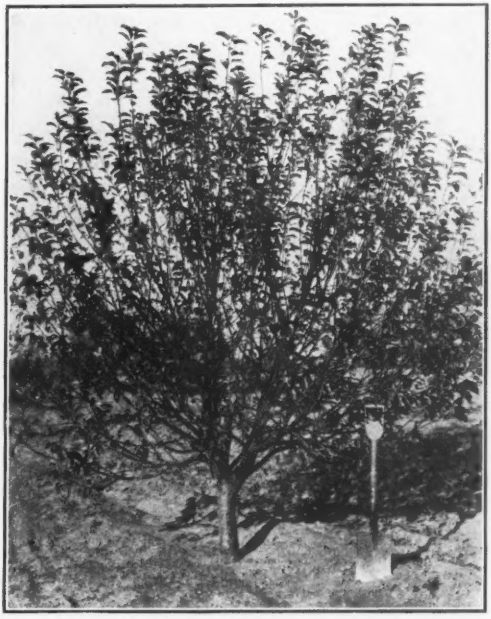

FIG. 17.—A Northwestern Greening apple tree planted in the spring, which has received treatment similar to that of the Wealthy apple tree shown in Figure 13. This is the largest apple tree in the garden. Akron, Colo., November

IRRIGATION

Although fruit growing on the average ranch in the Great Plains area must be largely under dry-farming methods, a relatively small quantity of water for irrigation may sometimes save fruit trees,

and especially strawberries and other small-fruit plants, during a particularly dry period.

Wells of large capacity and windmills are to be found on many ranches and often furnish an adequate supply of water for use in tiding fruits over a crisis of drought. On other ranches a supply of water for emergency use is sometimes stored in earth reservoirs, as suggested in Figure 22.

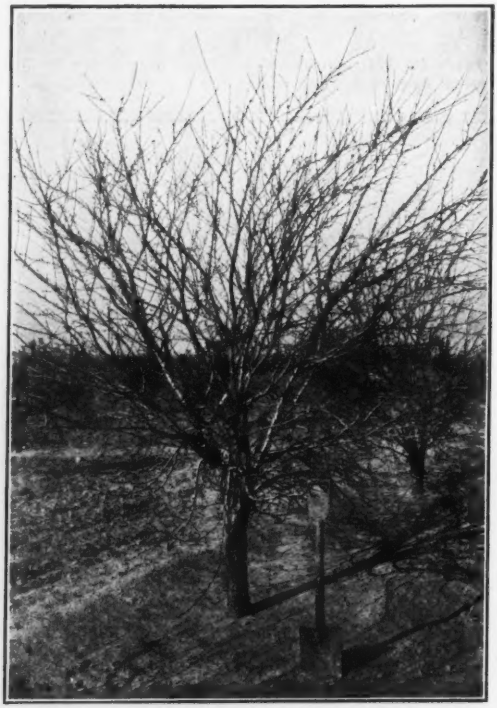

FIG. 18.—A plum tree of unknown identity planted in the spring, which is the largest tree of any kind in the garden, though during the growing season six years after planting the apple tree shown in Figure 17 nearly overtook it. It has received treatment similar to that of the Wealthy apple tree shown in Figure 13, but it is in better shape for a plum than the Wealthy is for an apple. Akron, Colo., November

Such a reservoir is made by excavating the earth and mounding it up somewhat about the edge or rim. The inside is then puddled with clay or in some other way made sufficiently impervious to water to prevent seepage. Obviously, it should be located if possible on a slightly elevated site. It may be filled from the ranch well when the water is not required for other purposes, and the water may be siphoned out when wanted for irrigation.

ORCHARD PESTS

The orchard pests in the Great Plains area are not known to be essentially different from those in other regions except as they are influenced by regional, primarily climatic, conditions.

On account of the comparative dryness of the atmosphere, fungous diseases are not as prevalent as in the humid regions, where conditions are more favorable for their development.

Insects, such as the codling moth and currant worm, may be expected to occur. It may be assumed that the methods of control that are effective in other regions will be equally effective in this area.

Rabbits are likely to injure young trees during the winter by gnawing the bark, and in some sections pocket gophers and prairie dogs may be troublesome. Information regarding the control of

these pests can be obtained by addressing the Department of Agriculture.

Sun scald sometimes occurs during the winter on the south or southwest side of the trunks, especially in the case of high-headed trees. Injuries of this kind can be prevented by shading the trunks in some way during the winter. Binding laths, narrow strips of board, or cornstalks about the trunks, or even wrapping them with newspapers, will furnish all the protection needed. The material used should be removed in the spring.

HAIL INJURY

The trees in the Akron fruit garden were once seriously injured by a hailstorm. The results may be of interest in connection with the handling of trees in other parts of this area which may be injured by hail. The oldest trees in the garden were completing their third season's growth when the storm occurred. The bark on the north side of the trunks and larger limbs of many of the trees was badly bruised, and in some instances practically torn from the trees. Nearly all varieties of apples and cherries sustained substantially the same degree of injury. There were several varieties of apples, however, that appeared as if by chance to escape in a slight degree, but it is hardly to be assumed that this was due to any greater resistance of these particular sorts to the hail. Most of the plum trees passed through this storm with relatively less injury than that received by the apple, pear, and cherry trees. The tops of the peach trees were practically killed.

FIG. 19.—A Desoto plum tree planted in the spring which has received treatment similar to the other trees, but as its tendency to branch is less pronounced the top never became as dense as some of the other sorts. Akron, Colo., November

During the two years following this injury the tops of a good many of the apple trees died, and to some extent those of other kinds also. The seriousness of the wounds on the trunks became very evi-

dent. In many instances where the tops were injured beyond recovery, good strong sprouts developed from some point along the trunks. The one best suited for renewing the top was selected and the original top cut away.

The results which followed such serious hail injury have made it clear that the wiser course as a rule is to dig up and discard trees that show severe damage, especially where they have been planted only two or three years. If they have reached bearing age, or nearly so, it may be worth while to do everything possible to aid the trees in outgrowing the injuries.

The hailstorm referred to was the only one that caused injury of any consequence in this garden during an 8-year period.

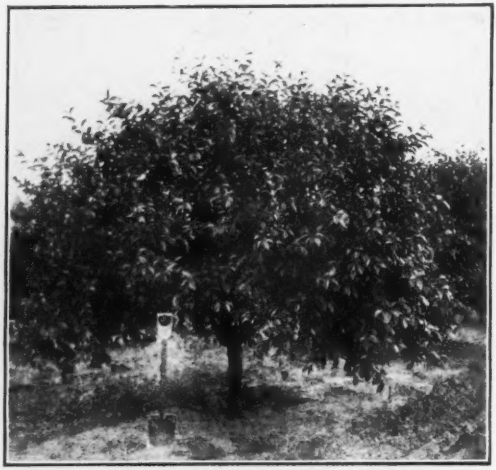

FIG. 20.—An Early Richmond cherry tree planted in the spring, an example of a tree that did not receive proper pruning and shaping of the top the first two years, but which responded fairly well to corrective pruning during the next three or four years. Akron, Colo., July

FRUIT VARIETIES SUGGESTED FOR PLANTING

Although the cultural methods used in fruit growing in this area have much to do with the measure of success that is attained, they are not more important than the selection of varieties that are adapted to the conditions. In fact, the choosing of the best varieties, especially of the tree fruits for planting in the different sections of the area is really more of a problem than to determine what methods of culture to adopt. This is true in a measure with regard to every region in which fruits are grown. But where the conditions, as in this area, are especially trying and present at best but a rather narrow margin between possible success and prohibitive limits, the problem of varieties becomes especially acute.

As mentioned in the discussion of the climatic conditions, the limited moisture, relatively low temperatures, and, in some parts of the area, a good deal of wind which increases evaporation make a combination of climatic influences that is very trying to fruit trees.

Not all varieties will do equally well throughout the Great Plains. In the southern part of the area the winter temperatures are much milder than they are in the north, but the wind is a more serious factor in the south than in the north. The very low winter temperatures reached in the north make it possible to grow only the fruits that have a high degree of resistance to cold.

Although very much yet remains to be determined with reference to the adaptability of varieties to the Great Plains area, it is believed that the mention of a number of different fruits which have been planted more or less may be suggestive and of some help to those who are without experience in choosing varieties to plant in this part of the country.

APPLES

Southern section.—A few of the varieties of apples that may well be considered for the southern part of this area are the Yellow Transparent, Red June, San Jacinto, Maiden Blush, Gravenstein, Wealthy, Grimes Golden, Jonathan, Kinnard, Northwestern Greening, Texas Red, Winesap, Missouri Pippin, Arkansas Black, Ralls, and Limbertwig; for crab apples, the Florence, Hyslop, and Dartt. These varieties, named approximately in the order in which they mature, represent a long sequence of ripening, from the early to the long-keeping sorts.

FIG. 21.—A Northwestern Greening apple tree planted in the spring at the Amarillo Cereal Field Station, Amarillo, Tex., as it appeared in July four years later. The prevailing winds have blown so incessantly as permanently to force the branches to grow largely in one direction, thus making an unsymmetrical top

Central section.—Most of the varieties that succeed best in the southern part of the area could doubtless be planted in the central section. However, the behavior of the fruits in the garden at the Akron Field Station may be used to further the information concerning varieties in this part of the area, at least so far as the growth of the trees is concerned. Reference to the various illustrations in this bulletin showing apple trees in this garden will be of assistance in this connection.

Among the apple trees in the garden that have made a good growth are the following varieties: Yellow Transparent, Oldenburg, Wealthy, Northwestern Greening, Patten, McIntosh, Jonathan, Longfield, Grimes Golden, Utter, Okabena, and several others; also the Hyslop, Virginia, and Florence crabs. Some of the newer apple varieties considered promising are: Anoka, Haralson, and Erickson, also the Dolgo crab.

These varieties appear to be sufficiently hardy to withstand the normal conditions in this region, but thus far they have been disappointing in fruit production. Though old enough to bear considerable fruit as compared with other sections, they have produced very little here.

A number of dwarf apple trees were planted during the first year or two following the establishment of the garden. These include the Yellow Transparent, Oldenburg, Gravenstein, Wealthy, Bismarck, McIntosh, Esopus Spitzenburg, and Northern Spy. Thus far these trees have done well, and their behavior is such as to make them seem rather promising. Dwarf apples can not be recommended for planting, however, until after they have more definitely demonstrated their value.

FIG. 22.—An earth "tank," or reservoir, for irrigating small gardens and fruit plantations

Northern section.—Naturally the varieties that can be planted in this part of the area must be restricted to the hardier sorts on account of the extremely low winter temperatures. These include the Oldenburg, Wealthy, Hibernal, McMahon, Northwestern Greening, Patten, Malinda, the Hyslop, Virginia, and Florence crabs, and possibly some others named in the Akron Field Station list for planting where the conditions are not too extreme; also the newer varieties suggested under the "central section" for trial. There are some localities in this section, however, where even the hardiest sorts would be of doubtful value.

PEARS

There are hardly enough pears now growing in this area to show the range of their possibilities, unless their comparative absence is to be interpreted as signifying that they are not well adapted to these conditions. The Kieffer, Duchess d'Angouleme (*Duchess*),

Bartlett, and possibly one or two other sorts are occasionally grown in the southern part of the area. A variety supposed to be the Warner has grown well at the Akron Field Station, but has produced only lightly. The Flemish Beauty is one of the hardiest sorts and sometimes succeeds farther north than most other varieties. Except in sections with more severe weather, the Sudduth, Tait, Parker, and Mendel are suggested for trial.

PEACHES

Peach growing in this area is largely confined to the southern section, where a considerable number of varieties are grown to a limited extent. These include the Alexander, Sneed, Triumph, Arp, Carman, Mamie Ross, Chinese Cling, Elberta, Heath Cling, General Lee, Lemon Cling, and others.

At the Akron Field Station peach trees, including a number of the hardier sorts, were killed to the ground, or nearly so, every winter.

PLUMS

Plums, particularly the native sorts, are among the most dependable of all the tree fruits on the Great Plains. They have been planted quite widely throughout most of this area, and there is a fairly large number of varieties from which to choose. Of these the following are named, especially for the southern sections: America, Desoto, Golden (*Gold* of Stark Bros.) Kroh (*Poole's Pride*), Pottawattamie, Six Weeks, Surprise, Wild Goose, Wolf, and Wyant.

Among the more promising varieties at the Akron Field Station are the following: Brittlewood, Emerald (*Burwood*), Cheney, Desoto, Surprise, Terry, Wolf, and Wyant. The identity of the plum shown in Figure 18 is unknown, but it is one of the most promising sorts in the Akron garden. It resembles the Brittlewood somewhat and may prove to be of that variety. Most of these varieties have been planted widely throughout the Great Plains area. Several varieties of European plums, including the Lombard, Arctic, Shropshire (Damson), and others, have also been planted at this station. None can be considered promising. The trees make only small growth as a rule, and do not satisfactorily withstand winter conditions.

In parts of the northern section the following varieties are grown more or less: Cheney, Desoto, Forest Garden, Surprise, Waneta, Wolf, and Wyant. Some comparatively new sorts that appear to merit testing are: Elliot, Red Wing, Tonka, and Underwood.

The native plum trees in the fruit garden at the Akron Field Station have not been very long lived as a rule. In fact, in nature where they occur in thickets, the perpetuation of the thickets is usually dependent largely on the growth of sprouts or seedling trees. The trees in the center, and others as they attain age, are likely to weaken and die. Therefore the grower should not be discouraged if he finds it necessary to replant plum trees every few years. It would probably be wise to make new plantings occasionally in anticipation of the loss of older trees through natural causes.

PLUM HYBRIDS

Among plum hybrids the Compass cherry, a hybrid between the sand cherry and the Miner plum, has been widely planted in this area. It is proving to be of distinct value. Trees planted at the Akron Field Station began bearing two years later and have produced fairly regularly. Though not of high quality, the fruit is very acceptable. The tree comes into bearing early and seems to be perfectly hardy at Akron. Figure 24 shows a Compass tree as it appeared in November four years after being planted. The tree makes a very open growth; practically no thinning out of branches has been done in the tree shown here.

A number of other sand cherry-plum hybrids and other plum hybrids have been planted. In general they are desirable for the Great Plains area, being hardy and seemingly well adapted to the conditions under which many other fruits fail. The Opata, Sapa,

FIG. 23.—Sand cherries planted in the spring, fruiting heavily two years later. Akron, Colo., July

Sansoto, Oka, Tom Thumb, Hanska, Waneta, Tecumseh, Kaga, and Radisson are considered the better known or more promising hybrid varieties.

CHERRIES

Of the tree fruits, sour cherries are perhaps of equal value with native plums for this area. The number of varieties commonly grown is small, the Early Richmond, Montmorency, and English Morello comprising nearly all the trees that have been planted; in fact, there are probably to be found many times more trees of a single variety—the Montmorency—than all the others combined. These varieties are successful generally in the central and southern sections, as well as in some parts of the northern section, but in the latter there are large regions where the conditions practically preclude the growing of cherries. The Zumbra, a recently introduced variety, is promising for some parts of the northern Great Plains. It is a supposed compound hybrid of a pin cherry, a sweet variety, and the sand cherry.

A 6-year-old Early Richmond cherry tree at the Akron Field Station is shown in Figure 20. Several trees of the Black Tartarian and other sweet cherries have also been planted at this station, but they have either died or are in an unsatisfactory condition. It is not believed that sweet cherries are likely to withstand the conditions anywhere in this area.

Sand cherries also do well in many parts of the Great Plains area. The ones shown in Figure 23 fruited two years after being planted. The fruit is of value primarily for making jelly or preserves rather than for use in the fresh state. But as the sand cherry is native to the Great Plains, doubtless selections could be made which would bear fruit of fairly good edible quality.

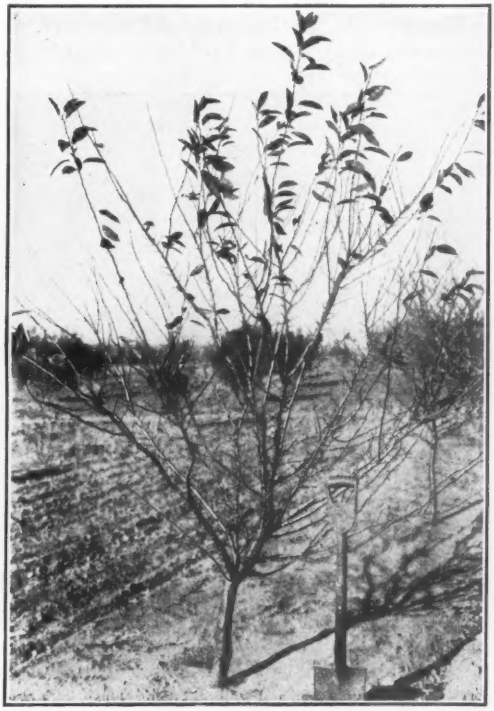

FIG. 24.—A Compass cherry 3 years old. The open spreading habit of growth is to be noted. Akron, Colo., November

CURRANTS

Currants appear to be one of the most satisfactory small fruits for the Great Plains. Most varieties do about equally well and are generally hardy. The London Market is perhaps grown in larger quantities than any other sort, but the Cherry, Victoria, Red Dutch and North Star, for red sorts, and the White Grape, for a white variety, have done well at the Akron Field Station. The Red Lake (*Minn. No. 24*) has been rather outstanding in yield and size of berry at the Cheyenne (Wyo.) Horticultural Field Station; the Diploma has also yielded well there.

The plants as a rule are a little slow the first year in getting started, but when well established they make a good growth if properly pruned. Figure 25 shows some currant bushes about 4 years old which are quite typical in growth of all the varieties at the Akron Field Station.

GOOSEBERRIES

In general, what has been said about currants is true also of gooseberries. They are quite dependable wherever currants are succeeding.

Like currants, the plants are a little slow in getting established and do not often make a very strong growth the first season. After they are once well established, they appear to be hardy. To keep them vigorous, however, the sprouts that habitually grow from the ground in rather large numbers should be kept well thinned out.

Probably the Downing, Houghton, and Poorman can be planted generally in this area with as much assurance of satisfaction as any other varieties. The Columbus has yielded especially well at the Cheyenne (Wyo.) Horticultural Field Station.

RASPBERRIES, BLACKBERRIES, AND DEWBERRIES

Raspberries, blackberries, and dewberries have not proved very successful in this area, and they have not been planted as a rule in the ranch fruit gardens. Generally speaking, they do not withstand dry weather well. Even in the humid sections heavy losses sometimes occur as a result of drought.

FIG. 25.—Currant bushes about 4 years old, showing typical growth, Akron, Colo., November

In many instances in this area the plants are slow in starting growth after being set out, though when once established the roots are quite persistent. The canes, however, are very apt to kill to the ground dur- the winter.

Of the varieties observed in this area there seems to be but little preference, as there has been no important difference in their behavior. Of the raspberries, the Cuthbert, Loudon, King, and Sunbeam, for red sorts, and the Cumberland, Kansas, and Winfield, for black varieties, have been planted at the Akron Field Station. They have all borne a little fruit; possibly the Sunbeam has done fully as well as any other red variety; the Cumberland may be preferred among the black sorts. The canes of all varieties have winter-killed so badly that there is little choice for planting. No winter protection, however, has been given them. The Latham is suggested for trial and the Chief and Newman are promising; these are red varieties.

Blackberries at the Akron Field Station have behaved in essentially the same manner as the raspberries. They are rather slow to start into growth after planting. The canes have been killed back

to the ground, or nearly so, every winter, and practically no fruit has been produced. The Himalaya, a variety the canes of which are perennial and normally do not die after producing a crop of fruit, as do the ordinary varieties, has made a fairly strong growth each year. However, it is not hardy enough to withstand the winters, though it does not usually kill back as far as do the other sorts. It has produced a very small quantity of fruit, which ripens over a long period, and only a few fruits are ever ripe at the same time, even on 10 or 12 large plants. The berries are small and imperfect, merest nubbins, and the proportion of seed to pulp is so large as to make the fruit almost inedible. Besides the Himalaya, the Snyder, Mersereau, and Rathbun varieties have been planted, none of which seem to be promising for this area.

Only one variety of dewberry, the Lucretia, has been planted. This bore a little fruit one year, but in general its behavior has been the same as that of the raspberries and blackberries.

Evidence is accumulating that the cane fruits, especially the raspberry, can be protected quite effectively during the winter by bending the canes to the ground along the row and covering them with 3 or 4 inches of soil. This may insure a crop in many cases, where failure would result without winter protection.

STRAWBERRIES

Success with strawberries in this area seems to be more largely a matter of the plants becoming well established and having an adequate moisture supply during certain periods than in the planting of any particular variety; in fact, the establishment of the plants is usually dependent upon a suitable amount of moisture in the soil. The roots are so near the top of the ground, at least until after growth has been well renewed, that they are very susceptible to the surface conditions of the soil. The roots of strawberries may dry out completely before a new growth starts, where other kinds of plants with their roots deeper in the soil would not be seriously affected. Hence, if newly set plants can be watered as needed until they are well reestablished after transplanting, the chief danger of failure in the beginning is eliminated. Unless this can be done, the plants will die in many cases before a new growth starts.

It is also important that water be available for use during the development of the fruit. At this period the strawberry requires a relatively large quantity of water. If it is lacking, the fruit will be small and much of it may fail to develop.

By mulching with straw during the winter to prevent repeated thawing and freezing as well as to protect the plants from extreme temperatures, strawberries can probably be grown almost anywhere in the Great Plains, provided water can be applied during the critical periods mentioned.

While irrigation might be quite advantageous at times in the growing of other fruits, it may often be practicable to water a small strawberry bed that can be located near the dwelling house, when it would be out of the question to water a fruit garden more or less distant from the buildings.

The Dunlap and Howard 17, with winter protection, are suggested for the northern section; these same varieties, together with the Beaver and the Rockhill (everbearing), for the central section; and the Klondike for the southern. The Dorsett and Fairfax appear promising for the central and southern sections.

MISCELLANEOUS BERRIES

Not many Juneberries have been planted in this area. As a rule they do not make a very vigorous growth, but appear to be hardy when well established and may be expected to bear considerable fruit. The fruit, while not of high quality, will add an agreeable variety for home use.

Of the wild fruits that are native to this area the buffaloberry is worth consideration, especially for the northern sections, where the range of fruits that can be grown is more limited than in other parts of the area. The fruit is small and very sharply acid. Its most important use is probably for making jelly, though it is eaten in the fresh state to a limited extent.

The fruit-producing blossoms of the buffaloberry are borne on separate plants from those that bear the pollen-producing blossoms. As only the former bear fruit, bushes for planting should be largely of that type, though a small proportion of the others must also be planted to supply pollen for the fertilization of the fruit-producing blossoms.

Selections of the highbush cranberry are suggested for the central and northern sections.

GRAPES

There is very little definite knowledge concerning the possibilities of grape growing in this area. Low temperatures in the north are largely prohibitive, but in some parts of the other sections it is probable that a measurable degree of success could be obtained, especially in localities where wild grapevines are found. Many varieties have been tested in recent years at certain of the dry-land agricultural field stations in the southern part of the area. Some of the varieties that have given promising results include: America, Beacon, Captain, Carman, Catawba, Delaware, Edna, Ellen Scott, Extra, Fern Munson, Headlight, Muench, R. W. Munson, and others. Beta and Alpha are hardier and can be grown farther north than most other varieties.

MIXED PLANTING ADVISABLE

Attention should be here called to the fact that many varieties of apples, plums, pears, cherries, and other fruits are more or less sterile with their own pollen. Such varieties, therefore, may be unfruitful, even though they blossom abundantly, unless planted in close proximity to other varieties of the same kind which blossom simultaneously with them. While not all varieties are self-sterile, and sometimes those which are so under certain conditions are not self-sterile under others, the matter is of too great importance to be disregarded when planting orchards or fruit gardens. It is therefore always wise to select at least two varieties of each kind of fruit for planting, unless one has good evidence that under his conditions a variety which he desires is self-fertile.

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